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MECHANIC ARTS MAGAZINE

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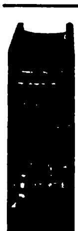

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THE MECHANIC ARTS MAGAZINE.

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Vol. IV. FEBRUARY, 1899. No. 1.

OUR CHANGE OF TITLE.

IN FUTURE, this publication (hitherto known as HOME STUDY MAGAZINE) will be called THE MECHANIC ARTS MAGAZINE. This change has been made because we believe that an educational journal should possess a name that indicates in an unmistakable manner the general character of its contents.

THE MECHANIC ARTS MAGAZINE, then, is an educational journal of the mechanic arts of engineering and allied industries. Its main object is to give information of practical value to students, and to those engaged in actual work in any branch of mechanical or civil engineering. With this end in view we shall see to it that the articles are well within the comprehension of all intelligent men—even of those who have had but few educational advantages; difficult mathematical solutions will therefore be avoided.

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Under the head of "Trade Notes," new machines and useful inventions will be mentioned. This department will also include general industrial information, business and educational notices, catalogue and book reviews.

As in the past, several pages will be devoted to "Answers to Inquiries," and we cordially invite our patrons to make this department as interesting and instructive as possible by sending us questions that arise in the course of their work or studies.

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THE MECHANICAL EQUIVALENT OF HEAT.

George A. Goodenough.

HEAT AND WORK ARE IDENTICAL—COUNT RUMFORD'S OBSERVATIONS ONE HUNDRED YEARS AGO. JOULE'S EXPERIMENTS—ROWLAND'S ACCEPTED EQUIVALENT OF 778 FOOT-POUNDS.

JUST about one hundred years ago, Count Rumford made the first rough determination of the mechanical equivalent of heat; though the story of Rumford's experiment is old, it is worthy of repetition. It had frequently been observed that heat is usually generated when mechanical work is done; and it was known at that time, as it is now, that a cutting tool will heat, or that a dry journal will warm its bearing. Rumford had speculated much upon this seeming connection between work and heat.

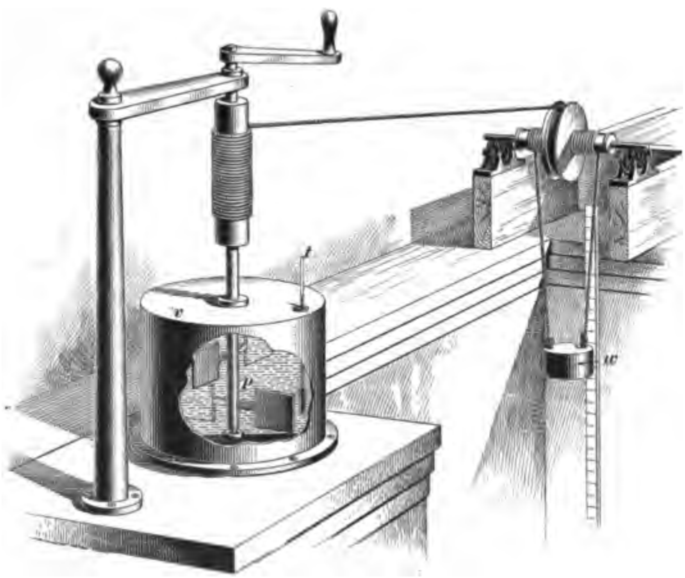


FIG. 1.

He was the superintendent of the cannon foundry of the arsenal at Munich, and had been led to study the subject by observing the heat generated during the boring of the cannon. In a truly scientific manner, Rumford proceeded to find by experiment if the heat generated during the boring of a cannon was proportional to the work done. For this purpose he enclosed a cannon in a wooden box filled with water, and bored it with a heavy drill, which was driven by two horses. The heat generated by the operation was absorbed by the water, and could be measured by the rise in the temperature of the water. At the beginning of the experiment, the water was ice cold, that is, at 32° F.; at the end of two and one-half hours, the water boiled. The power exerted by the horses could not be accurately measured; Rumford, however, stated that the work could have been done by one horse. Now, 1 horsepower is the power required to perform 33,000 foot-pounds of work per minute; therefore, the work done by the horse in 2½ hours, or 150 minutes, was $33,000 \times 150 = 4,950,000$ foot-pounds. The box contained 26.6 pounds of water, which was raised in temperature from 32° to 212° F. The English unit of heat is the heat required to raise 1 pound of water 1 degree Fahrenheit. Since, in this experiment, 26.6 pounds were raised 180°, the number of heat units generated in boring the cannon was $180 \times 26.6 = 4,788$. The experiment showed, therefore, that, to generate a heat unit, $4,950,000 \div 4,788$ (= 1,034) foot-pounds of work must be done. The value obtained by Rumford can only be regarded as a rough approximation to the true value; no allowance was made for the heat lost by radiation, and the power exerted by the two horses was probably not equal to 1 standard horsepower.

At the time of Rumford's experiment, it was generally believed that heat was a substance, a fluid without weight, which could readily flow from one body to another. This experiment showed quite clearly that heat could not be a substance, as was

generally supposed; for, if such were the case, the cannon could contain only a measurable amount of heat, and after a certain time it would cease to give it out.

The experiment of Count Rumford and those of Davy and Black, performed a little later, led to the belief that heat is simply a form of work, and that one may be converted into the other. This being true, there must, of course, be a numerical relation between the unit of heat and the unit of work; that is, a unit of heat must be equivalent to a certain number of units of work. Rumford's experiment, as we have seen, showed that the heat unit is equal to somewhere near 1,034 foot-pounds of work.

The first accurate experiments on the mechanical equivalent were made by Dr. Joule, of Manchester, England. The apparatus employed is shown in Fig. 1. By an arrangement of pulleys and drums, a paddle *p* was caused to rotate in a vessel *v* of water by the fall of a weight *w*. The work performed by the falling of the weight, except a small percentage absorbed by the friction of the moving parts, was expended in churning the water in the vessel. By means of a delicate thermometer *t* it was observed that the temperature of the water was raised by the action of the paddle. The rise of temperature must have been due to the heat generated by the paddle, since heat could have been applied to the water in no other way. Joule very carefully measured the work of the falling weight, and the heat imparted to the water. After making corrections for all possible errors, he found, as the mean of a great number of experiments, that 1 heat unit is equivalent to 772 foot-pounds of work.

An ingenious method of determining the mechanical equivalent is due to Hirn, a German engineer. He suspended by cords a block of sandstone *s* and a cast-iron cylinder *c*; between the two was hung a block of lead *l*, as in Fig. 2. In performing the experiment, the cylinder is raised to the position shown by the dotted lines, and is then allowed to fall and strike the lead block, the block of sandstone acting as an anvil, to receive the shock. The work done by the swinging cylinder is equal to its weight multiplied by the vertical height through which it falls; but, since the cylinder rebounds, the net work is the weight multiplied by the height of fall, minus the height through which it again rises. Part of this work done by the cylinder is spent in swinging the sandstone block into its new position; this work is the weight of the sandstone multiplied by the vertical height through which it rises. The remainder of the work must be done on the lead block, and must appear in the form of heat. The temperature of the lead is carefully noted just before the experiment, and just after. Knowing the rise of temperature and the weight of the lead, the heat given up to the lead can be calculated, and this heat is

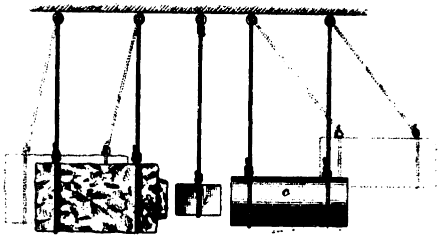


FIG. 2.

just the equivalent of the work done on the lead. Hirn found by this method the value of 774.5 for the mechanical equivalent.

Hirn also determined the mechanical equivalent by measuring the work done in the steam engine by a unit of heat. He measured the heat delivered to a large engine in a given time, and the heat delivered by the engine to the condenser during the same time. He found that the latter was in every case less than the former; that is, some of the heat contained in the steam was seemingly lost in passing through the engine. According to the theory that heat is simply a form of work, the heat lost in the passage through the engine should be exactly equivalent to the work given out by the engine. The difficulty of the experiment rendered an exact determination of the mechanical equivalent impossible; however, after making allowance for heat lost by radiation and otherwise, Hirn found the value 752 for the mechanical equivalent. The value of the experiment lies in the confirmation of the theory that heat and work are identical. A measured quantity of heat enters the engine, and a less quantity is given up to the condenser. Somewhere in the operation heat has been lost. The engine, however, does a certain amount of work, and the modern theory of heat asserts that this work is the exact equivalent of the heat lost. In other words, the heat is not lost at all, but reappears in the form of work. When heat is thus changed to work, or work to heat, there is a constant ratio between the number of foot-pounds of work and the number of

heat units. The value of this ratio is the mechanical equivalent.

The best and most recent determination of the mechanical equivalent of heat is that of Prof. Rowland, of Baltimore. He used an apparatus resembling Joule's in principle, but much larger. As the result of a series of careful experiments, Prof. Rowland fixed upon 778 as the most probable value of the mechanical equivalent, and it is the value generally used by engineers at the present time.

DRAFTING FOR THE PATENT OFFICE.

D. Petri-Palmedo.

A Few Hints From Experience to Draftsmen.

OUR patent system has caused the gradual development of a branch of the illustrative art, which may be called *patent-office drafting*, and which is peculiar in that, although a specialty in the art of drafting, it covers at the same time a most extensive field, and embraces a great multitude of subjects, as a glance through the pages of the United States "Patent Office Gazette" will show.

No matter what specialty a draftsman may have taken up, he is liable to be called upon at one time or another to do some patent-office work. The following hints are intended to supply him with the necessary information for the execution of such work; and although he will doubtless find therein much that is old in his special branch, it is believed that among the suggestions there are some that will be valuable to him. Thus, the illustrator engaged in preparing originals for photographic reproduction, while familiar with all the requirements of that work, some of which are common to it and to patent drafting, may glean information with regard to the more technical side of the latter branch; again, the machine designer or architectural draftsman, chiefly engaged in constructive work and the execution of working drawings for the shop, may find some things that he has had no call for in his line of work. On the whole, this article may serve as a general guide to those who wish to take up patent drafting as a specialty.

The United States Patent Office furnishes free, on application, a copy of "Rules of Practice." The book is a very handy one, as it gives, in general outline, the business methods followed in the office, together with much useful information as to how the drawings should be made. The rules given are in the main enumerated here, together with many additional suggestions not contained in the book.

All patent-office drawings must be made on "three-ply" bristol-board. Care should be taken in the selection of this paper; it should have a well calendered surface, be of even texture throughout, and stand rubbing well with pencil rubber and ink eraser. Two very good brands of bristol-board are Reynolds' and Designer's; the former is the harder of the two but is thinner, and ink erasures must be more cautiously made upon it than upon the latter kind; on the other hand, the surface of the harder paper is less liable to become "teased," or roughened, by frequent application of the pencil rubber. If a drawing is likely to be on the board a long time, the subject being complicated, the harder kind of paper will be preferable. Ink erasing should be avoided, but is absolutely necessary sometimes. The use of a knife for making erasures will be found very unsatisfactory, as, unless very carefully handled, the knife leaves a bad surface to make the corrections on. A Faber ink-erasing rubber, evenly and lightly applied, is much better, although requiring more time. After an erasure is made, the surface should be rubbed with a soft pencil rubber to remove the brimstone particles that have been forced into the paper by and from the ink eraser; finally, the surface should be smoothed down with the thumb nail or, better still, with a flat piece of polished ivory, which should be among the tools. A new surface thus prepared will take ink without blurring, and there will be hardly any evidence of a correction having been made except that, when held up to the light, the paper will show signs of being slightly thinned. With the hard, thin paper the limit to which erasures may be carried

is soon reached, and care must be taken not to rub through, as a sheet so injured will be returned from the patent office as "mutilated." A point in favor of the thin paper is that blueprint copies can be obtained from it more readily than from the thick paper. The fact that attorneys must keep copies of the drawings on file for reference makes this a matter worthy of consideration. For this reason, some attorneys insist on the draftsman using two-ply bristol-board; this is against the rules of the patent office, however, and such drawings are likely to be returned as "informal."

A good, sharp print can be obtained by turning the inked side of the sheet towards

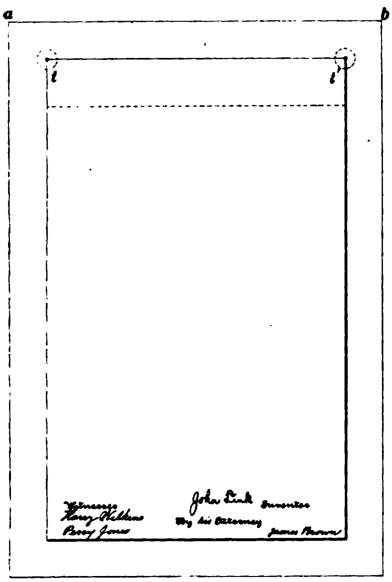


FIG. 1.

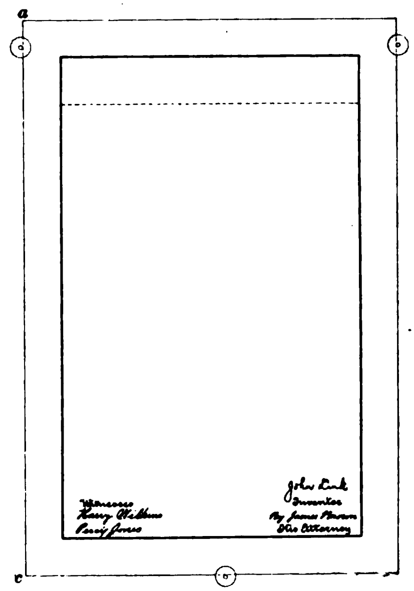


FIG. 2.

the sensitized paper in the printing frame; this, of course, reverses the copy, which is bad as far as the reference letters are concerned; on the other hand this objection is small in view of the greater sharpness of the lines. If a number of copies is required, which very often happens when the inventor wishes to have one or more for his private use, a good way is to make a reversed print on regular photographic silver paper, which will show white lines on dark-brown ground. This copy can be used to print through on ordinary blueprint paper, giving sharp blue lines on a white ground.

The patent office requires that the sheets be 10 inches wide by 15 inches long, with a black marginal line 1 inch from the edge all around. The left-hand lower corner must bear the names of two witnesses. The lower right-hand corner of each sheet must bear the name of the inventor and of his attorney. By mutual consent the first of the two witnesses is usually the attorney, and the second the draftsman who made the drawing. This is not without a purpose, for in patent litigations it is often desirable to be able to locate and examine on the witness stand the man who made the drawing. For this reason also, a patent draftsman should keep a memorandum book in which to note down the names of the inventor and of the attorney and the date in each case. He should also carefully preserve all sketches. All dealers in artists' materials keep in stock printed patent-office blanks of the proper size; if well made, these are very convenient and save much time. On the other hand, there are objections to these blanks; while the drawing is being made, the edges are apt to be injured and the corners turned over and torn off; sheets thus disfigured would not be accepted by the patent office. Again, it is necessary to run the thumbtacks through the sheet, leaving holes. For these reasons many draftsmen prefer to use the ordinary 13″ × 16″ sheets of bristol-board, as sold by the trade, rule and letter them themselves, and cut them to regulation size after the drawing is finished.

A very good plan obviating the troubles

just mentioned was suggested and is carried out for his own use by a New York attorney. The blank is printed in the ordinary manner, but not cut to size, the proper dimensions being indicated by depressed lines made by an embossing die. Thus there is, while the drawing is being made, an extra width of paper all around, which is cut off easily and accurately afterwards along the embossed lines. This is a very good plan, and is recommended to dealers for imitation.

A further requirement of the office is that, between the top marginal line and the uppermost point in the drawing, there shall be a clear space of 1¼ inches to be used by the office for the insertion of the name of the inventor and the title of the invention. As already explained, the lower right- and left-hand corners are occupied by signatures. There remains, therefore, for the drawing itself, a comparatively small space, which one has to economize as much as possible. For this reason, the blank should be so printed that the signatures occupy as little room as possible. Fig. 1 shows a blank in which much valuable space has been wasted, while Fig. 2 shows a very good arrangement, in which the space between the signatures is available for drawing purposes, which space is lost in the arrangement shown in Fig. 1. Very often this lack of space between the signatures proves to be an annoying matter. Another difference between the two blanks will be observed in the marginal lines. Fig. 1 shows the upper and the left-hand lines thin, and the lower and right-hand ones thick; this is evidently intended to show artistic taste on the part of the printer, but the heavy uniform marginal line of Fig. 2 is to be preferred. In order to make the holes of the thumbtacks show as little as possible, the draftsman will run the tacks through the corners of the marginal lines, and if these are heavy, the holes will hardly show at all. The paper being stiff, two tacks driven as at t and t', Fig. 1, will hold the sheet firmly. To avoid tack holes, the sheet may be fastened down, as in Fig. 2; but then three tacks are needed, and the lower one will always be in the way of the T square.

The patent office designates the edge $a\,b$ as the top of the drawing, and all views must, if possible, conform to this idea. In cases where the length of the figure is greater than its height, the sheet is turned around so that $c\,a$ is the top of the drawing, the signatures being then to the left. To this rule of the office it is well to add another; namely, whenever possible, all the sheets of one set of drawings should read the same way. This has the advantage that, when laying out the several views, and also when studying the drawings, the sheets can be handled with much more convenience by draftsman, attorney, and official examiner.

Although a patent-office drawing is mainly a picture, or illustration, it will pay the draftsman to work to scale, using the same scale for all views belonging together. This will not only greatly facilitate and expedite matters, but will make the drawings a good deal clearer, and the examiner will be able to see at once the relation of the various views to one another.

Suppose, for instance, that a certain machine is to be illustrated. We find that to properly show the complete mechanism

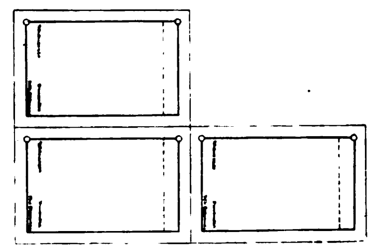


FIG. 3.

it will require a plan, a front view, a side view, and a longitudinal section of the whole machine, as well as various details. The draftsman may then tack three sheets on a large board, as in Fig. 3, and proceed as if he were making a regular working drawing. He will thus commence and finish all the three main views at one time. It is evident that the scale should be as large as possible. The details will naturally be drawn to a larger scale than the main views. By using the same scale for all the details, the reader of the drawings will much more easily see how the different parts of the machine fit together.

There is a great difference between the details of a patent drawing and those of a working drawing. In the latter the details consist, as a rule, of one or more views of each single piece of the machine, while in the former the details are intended to convey to the reader a more lucid conception of the operation of one particular part of the mechanism. Thus, if it were desired to make clear the forming of the loops in a sewing machine, two or more detail views of the shuttle and needle bar might be necessary, showing these parts in various successive relative positions towards each other. In

arranging the views one should strive to keep the various parts of the machine belonging together as much as possible on the same sheet. Thus, in the given example, the loop-forming mechanism should be shown—in as many views as necessary—on one sheet, and the cloth-feeding mechanism on another—that is, if both cannot be put on one sheet. When it was said a little while ago that the comparatively small space allotted should be economized, it was not meant that the views should be crowded. On the contrary, they should be kept well apart. In fact, the office requires that each view be distinctly separable at a glance from the others. Thus, an arrangement of views as indicated in Fig. 4, in which the plan cuts, as it were, the elevation in half, is not permissible. There is good reason for this: Every letters patent that is granted is made public through the official "Patent Office Gazette" by a single insertion of the claims and one illustration. This illustration is chosen from among the complete set of drawings, as, in the opinion of the examiner, being best suited to illustrate the invention. If, now, the views are so interspersed that one cannot be photolithographed without the other except by great trouble, there is more space needed in the "Gazette," than one patent is entitled to. If it is possible to leave a little blank space on each sheet without making it look too bare, it is well to do so for the possible addition of a small detail view here and there.

In regard to the selection of the various views, it is evident that no fixed rules can be given, as it will depend on the subject to be illustrated. Generally, however, the draftsman will have among the figures one that represents the whole invention, in a general way, as completely as is possible in a single view; in the case of a machine, this will probably be an elevation, taken from that side which shows the most of the mechanism. This main view generally constitutes Fig. 1, and serves a double purpose; firstly, it is intended to be the one to be published in the "Gazette," showing the subject of the invention in a general way without going into details; secondly, it is a very great help to the attorney, as well as to the examiner in the patent office. With the former it is the basis upon which to build his specification, and to which to refer when discussing the details. With the latter it forms the clue that at once places him in touch with the gist of the invention, and saves him the trouble of reading the whole specification to learn what it is all about. The fact is, the set of drawings should convey to the examiner a full understanding of the operations of a machine, without the specification. This is evidently what the office expects, for candidates for the position of examiner are given a set of drawings, and requested, as a proof of their qualification for the place, to briefly state the nature of the invention from the drawings alone. That a candidate who is unfortunate enough to be given a poor set of drawings will make also a very poor guess, is evident.

In the "Rules of Practice," we find the following sentence: "When the invention consists of an improvement on an old machine, the drawing must exhibit, in one or more views, the invention itself, disconnected from the old structure, and also, in another view, so much only of the old structure as will suffice to show the connection of the invention therewith." As a rule, this requirement cannot be strictly adhered to. Such improvements will generally be so intermingled with parts of the old machine scattered through it that a separation, as called for in the above rule, would make a drawing incomprehensible. A good way to separate new parts from old ones is to "shade up" the former only, and show the latter in outline, or even in dotted lines, as in Fig. 5.

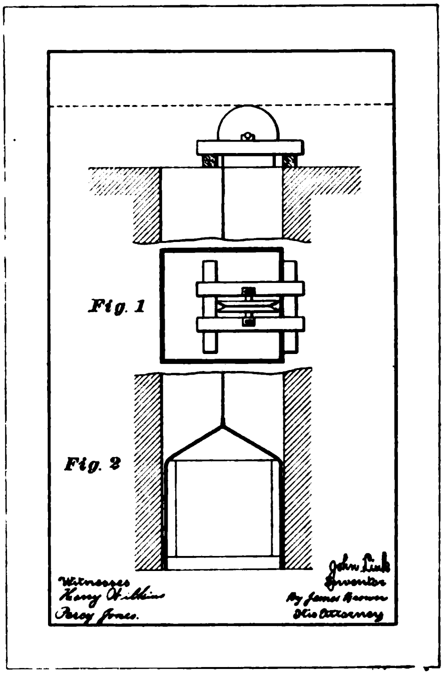


FIG. 4.

Views in perspective are justifiable in comparatively few cases. For illustrating machinery they are difficult and tedious to make, and are, consequently, expensive, and as a rule attorneys are not willing to pay for the extra time and labor. Besides, such

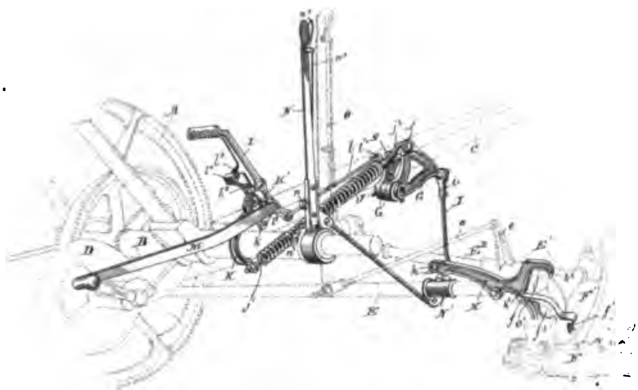


FIG. 5.

views, if not very skilfully done, have always a more or less awkward and unnatural appearance, as in Fig. 6, for instance. This is especially true when approximate perspective methods are resorted to, such as "cavalier perspective" and "isometric" drawing. As a rule, then, the draftsman will employ any of these methods as sparingly as he can, and only where they offer a decided advantage, as, for instance, when a single perspective view will more clearly demonstrate certain points than a number of rectilinear projections would (as in Fig. 7, for instance), or in cases where the *shape* of an object plays an important part, such as in collar buttons, garter hooks, shoes, etc., or as in Fig. 8, which represents a belt fastener. In this matter the draftsman must follow his own judgment.

In shading and in applying shade lines, the light is supposed to come from the upper left-hand corner at an angle of 45°, as is customary in most mechanical drawings. This applies to all the views. The patent office requires all lines, no matter how thin, to be perfectly black and sharp. This calls for the best kind of ink and the very best instruments, kept in perfect order.

Draftsmen engaged in illustrating work prefer generally to grind their own ink from a stick of Chinese, or India, ink. A thick slab of slate into which a dish has been turned, and having a still lower and smaller cavity at the bottom, makes a good ink well, and a glass cover keeps out the dust. In such a well (see Fig. 9) the ink keeps a long time and remains clean. Slate is much to be preferred to china for ink slabs, as the stick can be ground much faster on it. Tepid water accelerates the process of ink rubbing. The commercial liquid inks are less suitable for patent-office work, although they are much used. The best of these liquid inks is Higgins's American Drawing Ink, of which there are two brands, namely, "general" and "waterproof." The latter is not so intensely black as the other, does not flow as easily, and is more troublesome for the pen. The "general" ink is, therefore, to be preferred for fine work.

With respect to instruments, every draftsman will have his own way. In selecting a ruling pen, however, one will do well to choose a "duplex," as shown in Fig. 10. This is adjusted for the thin, unshaded outlines of the drawing by the screw *a*, and for the shaded outlines by a screw *b*. By pressing lever *c* against the end of screw *b*, the pen opens for a shade line; by letting go the lever, it closes on screw *a*

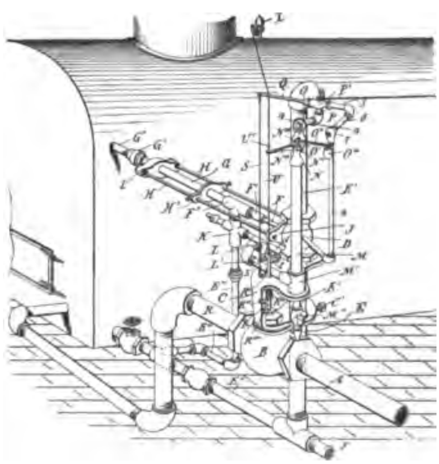


FIG. 6.

for a thin line. With this pen one can "ink in" a drawing much faster, and at the same time have all the shade lines of equal width.

For a **T** square, one with a thin blade (2 inches wide by $\frac{1}{16}$ inch thick) of transparent celluloid is strongly recommended. Triangles should be of the same material. The transparency of the **T** square and angles is

valuable, if for no other reason than this, that all dust and ink or pencil marks are easily detected and cleaned away before soiling the white sheet. Otherwise, hard-rubber blades and triangles would answer as well—the flexibility being common to both materials. It will be evident from the above that squares and triangles of wood with transparent celluloid edges, which were offered by the trade some time ago, are of no earthly use.

For penciling on bristol-board a very hard pencil should be used—Faber's HHHHHH,

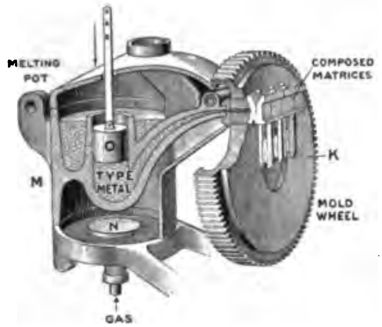


FIG. 7.

for instance. It should be used very lightly, as any considerable pressure will leave indentations that will never come out again. On the other hand, soft pencils will leave lead marks, which no amount of rubbing will remove.

Of rubbers the draftsman should have three kinds for pencil, and, as has been already stated, a medium hard ink eraser for ink. The pencil rubbers should all be soft, but not of the same *degree* of softness. One should be quite stiff, "Davidson's Velvet," for instance. This is to be used, while penciling in, to remove any obstinate lines and spots. While penciling, the cleaning process should be going on continually, as on the inked, finished drawing there should be as little rubbing as possible. The second grade of rubber, which should be softer than the first, is for general use. A "multiplex" is good for this; it consists of a multitude of layers vulcanized together. The third grade should be the softest of the three. For this, a sponge rubber or very soft solid rubber is suitable. If sponge rubber, it should be of the gray, not the black, kind—the latter dirties the paper.

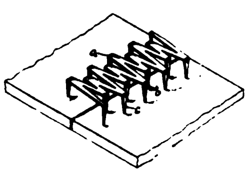


FIG. 8.

We take it for granted that the reader knows that patent-office drawings are reproduced by the lithographic process, and that, therefore, they must be executed with the pen only; that is to say, no brush washes are permitted. Draftsmen who have not had a great deal of experience with freehand work and lettering will find some difficulty in handling the common pen for shading and lettering. This is purely a matter of practice. Some artists are able to do with ease as fine work with a common pointed writing pen as others with the finest ruling pen. But these are exceptions. For lettering and freehand

FIG. 9.

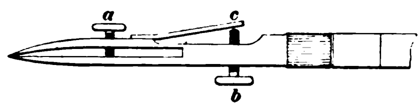


FIG. 10.

work, "Gillott's long shoulder, crown quill, No. 850" will be found to answer very nicely.

That drawings should be made with as few lines as is consistent with clearness is another rule. The draftsman will therefore strive to bring out convex or concave surfaces with so-called "open" shading rather than by many fine, close lines. The difference between the two methods is illustrated in Fig. 11, at (*a*) and (*b*).

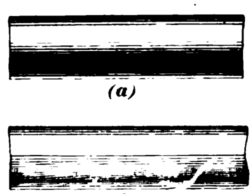


FIG. 11.

The main object of a patent drawing being

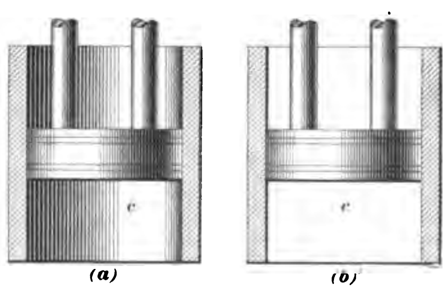


FIG. 12.

to convey a full understanding of the invention rather than to show a completely finished picture, the draftsman is at liberty to leave parts unshaded if by so doing the view will

be clearer. Thus, if in a section there are two or more superimposed cylindrical surfaces, he may leave out the shading on one or two of them [see Fig. 12, (*a*) and (*b*)]. View (*b*) does not look artistic, but is a great deal clearer than (*a*). As a matter of fact, in cases like Fig. 12, the shading of the concave

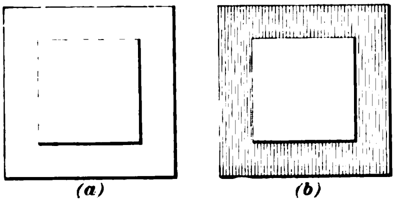


FIG. 13.

cylindrical surface *c* is almost invariably left off. In the same manner plane surfaces are usually not shaded, except in perspective views, and in cases where several of them are superimposed, and where clearness demands that the surfaces be distinctly separated [see Fig. 13, (*a*) and (*b*)]. In such a case, equidistant thin lines are used, either horizontal or vertical. Section lining is, as usual, made with oblique parallel and equidistant lines as open as the case will permit.

The plane upon which a sectional view is taken should be indicated on the general

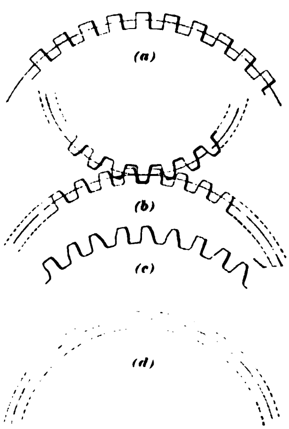


FIG. 14.

view by a broken or dotted line. Usually, draftsmen use for this purpose a line like this: ———-———-. In connection with section lining it may be well to state that so far no machine has been invented which usefully facilitates this work. The best "section liner" is a trained eye and skilful hand. To this matter the beginner should pay considerable attention, as nothing spoils the appearance of a drawing more than uneven section lining. A drawing thus faulty is at once a telltale on the beginner and amateur.

Under the same head come a good many other things which will distinguish the work of an experienced man from that of a beginner or a poor workman. Here are a few instances. No one who has ever seen a gear-wheel draws the teeth as in Fig. 14 (*a*), but makes them look shipshape, as in (*b*). They should be made with the compass and correctly spaced. Rather than indicate them either faulty in shape as at (*a*), or carelessly by hand as at

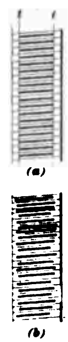


FIG. 15.

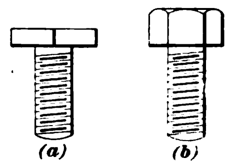


FIG. 16.

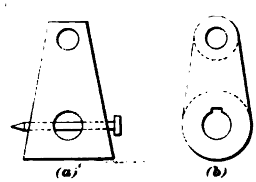


FIG. 17.

(*c*), the teeth should be left out altogether and dotted lines shown, as in (*d*). The pitch circle should always be indicated by a dot-and-dash line. Sometimes this alone will serve to indicate a gear-wheel. Here a little trick will prove a great saving in time. The correct spacing of a gear is troublesome and tedious. Now, instead of showing the teeth all around,

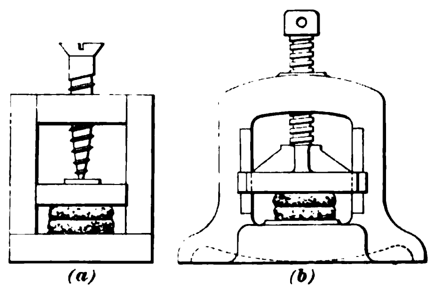


FIG. 18.

methods (*b*) and (*d*) may be combined; that is, the actual teeth need be shown only near the point of mesh, and dotted lines used for the rest of the circumference.

Another troublesome thing to draw is a screw thread. If not too large, the conventional way of indicating a screw thread,

as shown at (*a*), Fig. 15, may be used. Here it is well, while laying out the screw, to draw two faint pencil lines *t*, to guide the

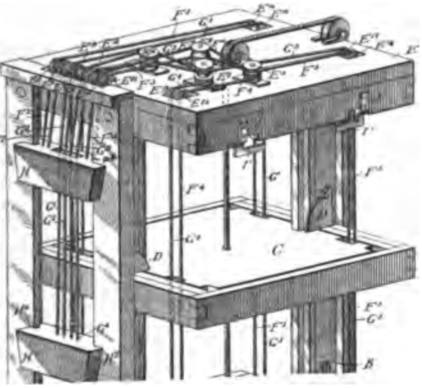


Fig. 19.

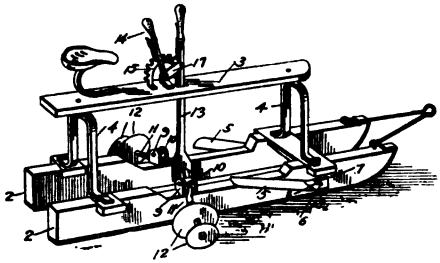


Fig. 20.

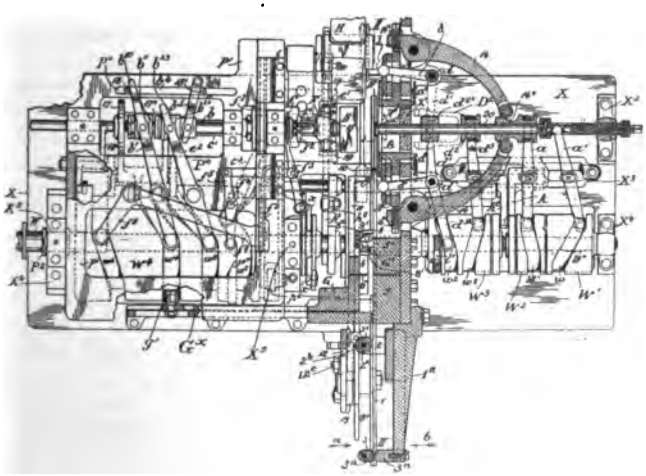


Fig. 21.

eye as to the length of the heavy dashes. Without this precaution, and with careless spacing, the thread may look like (*b*), Fig. 15. Draw the thin lines first, spacing them nicely, and fill in the thick lines afterwards.

We could add numerous things of like nature, but the draftsman will soon hit upon

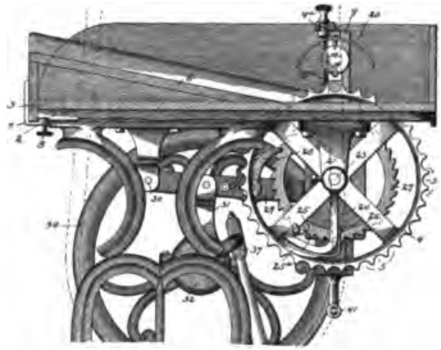


Fig. 22.

the various little advantages himself. If he has eyes to see, he will not draw bolt heads and nuts as flat as a pancake, like (*a*), Fig. 16, but as high as the bolt at (*b*), Fig. 16. Nor will he draw the crank of an engine like (*a*), Fig. 17, just because the inventor has made it so, and whittled it out of a piece of kindling wood, for his model, but like (*b*), Fig. 17. He will not indicate a pressure screw like (*a*), Fig. 18, because in the model he finds a wood screw used for the purpose, but will show it somewhat like (*b*), Fig. 18.

Fig. 23.

Illustrations of what perpetrations in the way of drawings the official examiners have to contend with, are given in Figs. 19 to 23. The first shows an elevator with ponderous beams and platforms, but little cotton-thread spools for sheaves and pulleys. Fig. 20 is supposed to represent a corn-cultivating machine. It is quite probable that the examiner at first glance took it to be some new steering device for children's sleighs. Fig. 21 is an example of a very confused and indistinct drawing. Fig. 22 is a case of too much surface shading, and Fig. 23 a case in which the examiner must be in

doubt whether the subject matter of the patent application is a method of producing novel tonsorial effects or is a porous plaster, while in reality it is a shoulder brace.

All these things may seem trifling, but a draftsman engaged for any length of time in patent-office drafting is very apt to lose sight of the mechanical side of his work. A story is told of a patent draftsman for many years connected with one of the great "patent mills" in New York, where they grind out applications by the hundred every day. This man would not pay much attention to the gist of the invention, but would portray a model just as it was placed before him. Knowing his weakness, his colleagues built up a bogus model from an old inkstand, hairpins, and other trumpery. A bright silver dollar was made to serve as a gear-wheel and a dime as a pinion. All this was placed on his desk. Three hours later a true likeness of this conglomeration was handed by him to the chief draftsman, together with the bogus model—minus the $1.10.

From the great diversity of the subjects that a patent draftsman has necessarily to deal with, it will be apparent that he must not only be an all-round good draftsman, fully versed in projection, perspective, and shading, but a good freehand artist as well. An eye for beauty and conventional forms and shapes is very essential, and a knowledge of machine design will enable him to surmount many an obstacle and gain him many favors from attorneys and inventors alike. If he be gifted with a certain amount of inventive genius himself and be possessed of a vivid imagination, he will be the more fortunate.

In the majority of cases the information supplied the draftsman to work by is very meager, incomplete, and unsatisfactory, consisting of poor sketches, a few notes, or an oral explanation by the inventor, either direct, or, what makes matters worse, through his attorney. Oftener than is pleasant, the inventor himself has no clear conception of the details of his invention and expects the draftsman to supply the deficiency, and if the draftsman wishes to get the job he must submit to it.

When the draftsman is furnished with a model his work is a great deal easier, and by the exercise of a little judgment, with respect to proper proportions and shapes, as already indicated, he will generally succeed in making the drawing look as if the machine which it represents might work, even if the model never did.

Often, again, a complete working machine is available, if only for such a length of time as will enable the artist to make the necessary sketches. As time is money, he will make these sketches as quickly as he can. A good training in freehand drawing will help a great deal. An excellent plan is to procure a pad of "cross-section" paper ruled with ⅛-inch squares, about the size of the available space on the patent-office sheet, say 8 in. $\times$ 10 in. Out of every sheet of cross-section paper, of the size sold by the trade, he can make 4 sheets for his pad. Armed with this pad, half a dozen sharpened pencils (Faber No. 3), a pair of compasses, a foot rule, and a piece of rubber, he will proceed as follows: Measure the total length, height, and width of the object; then, comparing these dimensions with the size of the pad, decide on the scale of the main views, and mark it down. Lay out a base line, some three or four principal dimensions, as distances from base line to center of main shaft, etc., and then fill in the rest by eye. If he gets the salient points of the machine down on his pad he will most likely remember the details. If the machine is complicated, a $5'' \times 8''$ camera will be a great help, especially if the machine cannot be kept idle for any length of time, which is often the case. A patent drawing is not seldom made from memory alone.

As I walked by myself,
I talked to myself,
And the selfsame self said to me,
Look out for yourself,
Take care of yourself,
For nobody cares for thee.—*Owen.*

THE CYCLOMETER.

Carl G. Barth.

How the Mileage Is Recorded—Why a Cyclometer Seldom Registers the Actual Distances Covered by the Bicycle—Variations of Records and Their Causes.

THE *steel steed* had probably not been very long in use before it occurred to some mechanical genius that there might be a fortune in store for him if he could get up a "something-or-other" that would enable the modern knight errant to ascertain, at any time, the distances he covered in conquering new territory. Whether it brought its inventor the expected fortune, or whether somebody else made the fortune and forgot to share it with the deserving inventor, we do not know. However this may be, this wonderful something-or-other one day made its appearance in the cycling world, to which it was introduced under the name of cyclometer.

Fig. 1.

"Well," I hear some of my good readers say, "there is surely nothing wonderful about a cyclometer!" But stop to think for a moment, and try to remember how the matter presented itself to you the first time you saw one. You surely did not guess what it was for; and when, on inquiring, you were enlightened on that point, you probably knew very little more about the instrument than you did before.

That the instrument is not a self-explanatory contrivance is fully demonstrated by the story of one of the earlier riders who, on hearing of the cyclometer, sent for one, and, on receiving it, fastened it to the handle bar of his machine, and then wondered why it failed to work.

The fact is, a cyclometer is both an ingenious and interesting little machine; and a few moments spent in getting more intimately acquainted with it will probably not be misspent.

Suppose, then, we examine an ordinary watch-like cyclometer, as shown in Fig. 1, with a view to acquire a full knowledge of its working mechanism. When in use, it is attached to the axle of the front wheel of the bicyle by means of the slotted tongue a, with its star, or spider b, turned towards the wheel. Clamped to one of the spokes of the wheel is what may be called a *wiper*, which is generally nothing more than a small projecting roller by means of which motion is communicated from the wheel to the spider, and thence to the rest of the mechanism in the cyclometer. This wiper is so adjusted that, in actuating the spider by engaging with one of its five arms, it will just move that arm over to the position previously occupied by the preceding one, so that the spider and its shaft will be turned just one-fifth of a revolution once in each revolution of the wheel. The dial of the instrument is provided with four holes, marked, respectively, *thousands*, *hundreds*, *tens*, and *units*, through each of which is seen one of the figures that, by the peculiar mechanism of the instrument, are made to travel past these holes in such a manner as at any time to indicate the total mileage covered by the rider. It is further provided with a graduation around its circumference, on which a pointer e indicates the fractional mileage, to a hundredth part of a mile.

Let us now take the instrument apart and examine its hidden mechanism. Removing, first, the glass cover over the dial, which, without being hinged, is otherwise held in place in the same manner as the crystal of a watch, we then readily remove the dial itself, by taking out the two small screws c, c (Fig. 2, A) with which it is secured. This at once exposes nearly the entire inside mechanism, the whole thing now appearing as at B in Fig. 2. On examination, we find that the shaft of the spider is provided with a screw thread, which is

seen to interlock with the teeth on the outer circumference of a thin brass ring, or worm-wheel *d*. This wheel is held in position by resting on an annular step, or ledge, in the bottom of the case, against which it is held by the two small projections *g*, *g*. We also find that the pointer *e*, which, when the cyclometer is in use, moves intermittently around the circumference of the dial and indicates fractions of a mile, is attached to the end of a pin *f*, which is riveted into the worm-wheel; and we now see that the small movement the pointer makes every time the wheel of the cycle makes a revolution is produced by the action of the spider-shaft thread, or worm, on the teeth of the worm-wheel *d*.

We also readily see that the pin *f* is the means of communicating motion from the worm-wheel to the rest of the mechanism, which, in the main, consists of four *double-decked*, round pieces *h*, *i*, *k*, and *l*, each of which is mounted on, and capable of rotating on, a stud riveted to the bottom of the case, and has all the ten figures printed upon its upper cardboard deck. It is evidently these various figures that appear at the proper moment through the four holes in the dial, and thereby indicate, or count off, the mileage, for which reason we will hereafter refer to those four double-decked, figure-carrying pieces as the *counters*. We further see that the lower deck of the units' counter *h* is of a different form, or outline, from those of the other three, which are alike; and also that, while the upper decks of all four counters are on the same level, the lower decks are on different levels, as plainly shown in Fig. 3, where, for convenience in illustrating, the four counters are arranged in line.

Supposing, now, we remove the upper decks in *B*, Fig. 2, so as to expose the lower ones, as in *C*, Fig. 2. We then see that the lower deck of the units' counter has ten equal, shallow scallops, or notches, cut into its circumference, which leave as many points, or teeth, between them; and, likewise, that each of the lower decks of the three remaining counters has, similarly, ten equal notches in its circumference. The lower decks of the counters thus become little 10-tooth gear-wheels, or pinions, and we will accordingly hereafter refer to them as such.

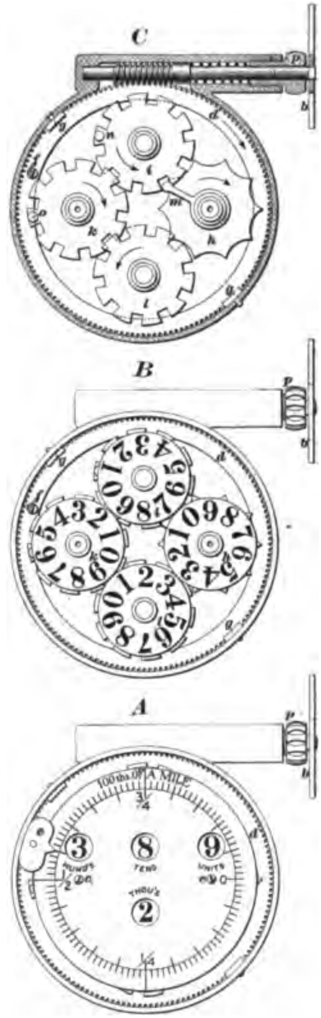


Fig. 2.

The pinion of the units' counter is evidently actuated by the lower round part of the pointer pin *f*, as this is being advanced one tooth in every complete revolution of the worm-wheel *d*. This pin *f*, then, acts as a wiper on the pinion, just as the wiper on the wheel of the cycle actuates the spider. On further inspection, we also find that this counter has a little arm *m* on the upper side of its pinion. This arm is on the same level as the lower deck of the tens' counter, and is also a wiper, by means of which the units' counter advances the tens' counter one tooth once in every revolution of itself. Again, we see that one tooth on the pinion of the tens' counter has a little pin *n* driven into it. This, too, is a wiper, by means of which the tens' counter imparts motion to the hundreds' counter.

Finally, we find that one tooth on the pinion of the hundreds' counter is provided with a similar wiper *o*, by means of which it advances the thousands' counter one tooth in every revolution of itself.

The little notches on the under side of the hubs of the counters (plainly seen in Fig. 3), which engage with the tooth-like projections on the upper surface of the two flat springs in the bottom of the case (see Fig. 4), are evidently for the purpose of giving precision to the position and movement of the mechanism, which would otherwise be entirely loose and indefinite. The spring around the

spider shaft (see Fig. 2, *C*) serves a similar purpose by preventing end play of the same.

As each counter has ten teeth on its pinion, and also ten figures on its upper deck, it follows that, every time it is moved one tooth by its actuating wiper, it will present to view its next higher figure. Again, it is obvious that, every time a counter indicates

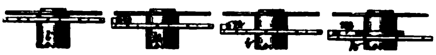


FIG. 3.

9, its wiper is in position to actuate the next counter; so that, on advancing to indicate *0*, it will, at the same moment, advance the next counter one tooth. We can now readily understand how our cyclometer reached its present reading of 2,389 miles.

As the bicycle proceeded and the wiper on its front wheel actuated the spider of the cyclometer, the worm on the spider shaft turned the worm-wheel *d*, and with it the pointer pin *f* and the pointer *e*, which latter indicated, at any moment, the fractions of a mile covered by the bicycle. Now, as on the completion of every full mile, the pointer passed the *0* mark, its pin caused the units' counter to advance one tooth, and thus indicated an additional mile. Every ten miles covered by the bicycle the wiper on the units' counter advanced the tens' counter one tooth, and thus made it indicate an additional ten miles. Similarly, every hundred miles the tens' counter had made one complete revolution, and then its wiper advanced the hundreds' counter one tooth, and thus made it indicate the additional hundred miles traveled. In a similar manner the hundreds' counter actuates the thousands' counter at the end of every thousand miles covered.

Having thus become fully acquainted with the working mechanism of the cyclometer, it remains to satisfy ourselves of the reliability of the instrument. To this end we first count the number of teeth in the worm-wheel *d*, and find the same to be 144. From this it follows that the spider shaft must make 144 complete revolutions to cause the pointer *e* to travel once around the dial, and thereby indicate one mile. But, as the spider has five arms, the wheel of the bicycle must make five complete revolutions for each revolution of the spider, and, hence, $5 \times 144 = 720$ revolutions for each mile recorded. If the instrument is correct, the bicycle must then cover exactly one mile for every 720 revolutions of its front wheel; or, in other words, the circumference of this wheel multiplied by 720 must equal 1 mile, or 5,280 feet. Dividing, therefore, 5,280 feet by 720, we must get the circumference of the wheel expressed in feet; that is, the circumference must be $\frac{5{,}280 \text{ feet}}{720} = 7\frac{1}{3}$ feet $= 7\frac{1}{3} \times 12 =$ 88 inches. Dividing this figure by the ratio of the circumference of a circle to its diameter, which is 3.1416, we then get the diameter of the wheel, which will be $\frac{88 \text{ inches}}{3.1416} = 28.011$ inches. This, then, is what the diameter of the wheel of the bicycle must be in order that this cyclometer shall correctly register the distances covered. Now, as manufacturers aim at making the standard bicycle tire exactly 28 inches in diameter when fully inflated, we see that this particular cyclometer itself introduces a slight error of reading. The *effective* diameter of the wheel, however, will not be even 28 inches, but will depend upon both the degree of inflation of the tire and the weight of the rider (which latter will cause a greater or lesser flat on the part of the tire in contact with the ground), and will thus fall considerably below 28 inches. The effective diameter is, therefore, probably never more than 27.5 inches, in which case the error of the cyclometer reading will be equivalent to recording 28,011 miles instead of 27,500 miles, which is again equivalent to $\frac{28{,}011}{275} = 101.86$, instead of 100 miles; this can be expressed as an error of a little less than

FIG. 4.

2 per cent. When the effective diameter is as small as 27 inches, the error will, therefore, amount to about $3\frac{3}{4}$ per cent. This is probably a figure never reached by a rider

who pays proper attention to the inflation of his tires.

As the accuracy of the cyclometer reading thus depends not only upon the cyclometer itself, but also upon the diameter of the front wheel of the bicycle, the careful rider always determines his individual average error by riding over a correctly measured piece of road and comparing its true mileage with that registered by his cyclometer. He is then at any time able to make the proper allowance for the necessarily somewhat erroneous reading of his instrument.

THE HYDRAULIC JACK.

C. P. Turner.

How One Man Is Enabled to Lift an Enormous Load—The Hydraulic Jack and How to Ascertain Its Lifting Power.

ONE of the most useful and powerful devices by means of which a man is enabled to exert his strength so as to lift a heavy load is the hydraulic jack. This machine combines great force with simplicity, security, and efficiency to an extent that is almost impossible with any other arrangement that has ever been invented.

Fig. 1 shows the construction of a common type of hydraulic jack that is suitable for any place where heavy weights are to be lifted. It consists of a hollow base *a* that is bored so as to form a cylinder in which works the ram *f*. A cup-shaped leather *m*, held in place by the nut *n*, provides a packing that effectually prevents any water from leaking out of the cylinder past the ram. The ram is hollow, and carries a hollow casting *A*, which provides a closed chamber at its upper end. A small force pump is fitted into the upper end of the hollow ram, with its plunger *h* extending up into the chamber, where it is attached to a lever *p*. The lever *p* is securely fastened to a short shaft *d*, which works in the bearings *e* and *b*. The end of the shaft *d* is square, so that a long lever for working the pump can be easily slipped on when required.

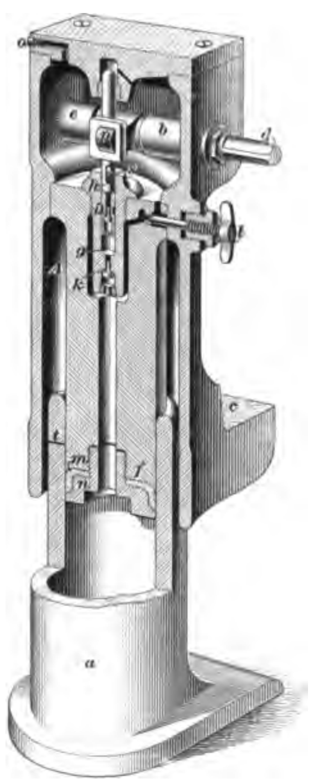


Fig. 1.

Now, suppose that the ram is at the bottom of the cylinder and that the space in the cylinder around the ram, together with the hollow space in the ram and the chamber above it, are completely filled with water; by swinging the lever attached to *d*, the plunger *h* is lifted and water flows in through the opening *s* and the valve *i* so as to keep the space in the pump cylinder *g* filled; then, by pushing the lever in the opposite direction, *h* is forced down into its cylinder. As *h* descends, the valve *i* closes and prevents the return of the water into the chamber, but the valve *k* opens so as to allow the water to be forced down through the hollow ram into the cylinder *a*. This cylinder being full, the entering water forces the ram upwards and with it any weight that may be on either the top or the claw *c*. By repeating the motions of the lever, the water in the chamber is gradually forced down into the cylinder, while the ram with its load is raised. To lower the ram, the key *l* is turned so as to allow the water to flow back into the upper chamber. The upper chamber is filled through the opening closed by the plug *o*. In order to guard against forcing the ram clear out of its cylinder, a small hole is provided at *t* which

allows the water to escape as soon as the lower end of the ram reaches that point.

In order to understand clearly the action of the hydraulic jack it will only be necessary to refer to a well known principle of the action of water under pressure, which may be illustrated by the following simple experiment:

Take a large cylinder *a*, Fig. 2, and fit a piston *b* so as to work easily in it. Connect a smaller cylinder *c* to the first, as shown, fitting a piston *d* to this cylinder also. Fill the cylinders and connecting pipe with water until the pistons stand at the same level and some distance from the bottoms of the cylinders. If one piston tends to rise while the other sinks, load it until they both stay at the same level.

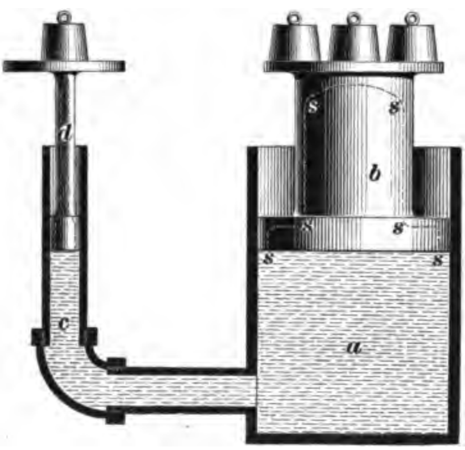


FIG. 2.

Suppose the area of the under side of the piston *b* to be 100 square inches, while the area of the under side of *d* is only $\frac{1}{10}$ as much, or 10 square inches. Now put a weight of one pound on the piston *d*; it is seen that the pressure produced in the water in *c* by this weight is transmitted through the pipe connecting the two cylinders and acts to lift the piston *b*; we also find that in order to make the pistons balance again we must put 10 pounds on the piston *b*. We can go on adding weights to *d* and we will find that for each pound added, 10 pounds must be added to *b* to make the pistons balance. If we make the area of the under side of *d* only 1 inch instead of 10 inches, we will find that for each pound put on *d* it will be necessary to add 100 pounds to the weight on *b*; and, for any ratio between the areas of the two pistons, it will be found that the ratio of the weights that must be added is the same as the ratio between the areas of the pistons.

Another point of interest will be shown by this apparatus; that is, that it makes absolutely no difference in the amount of weight that must be added to *b* in order to balance a given weight on *d*, whether the under side of *b* is a smooth flat surface, or whether it is hollowed out in any shape, for example, as shown by the dotted line *s s s s*.

By comparing the hydraulic jack with the results of the experiment, we see that it consists of two sets of cylinders and pistons connected by a tube and arranged in a form that is convenient for use as a machine for lifting weights. The weight to be lifted rests on the large piston, while the pressure on the small piston is produced by the pressure on the lever fastened to *d*. By the action of this lever a man is able to push down on *h* with a pressure several times as great as the pressure he puts on the end of the lever, and the resulting upward pressure on the ram is as many times greater than the downward pressure of *h*, as the area of the under side of the ram, considered as a flat surface, is greater than the area of the under side of *h*. It is thus seen that the lifting power of the jack may be made almost as great as we please by making the ratio of the size of the ram to that of the plunger great enough. This ratio is made great enough in some jacks so that one man can lift a load of more than 100,000 pounds.

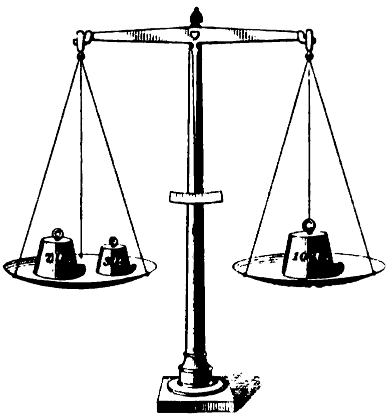
ALGEBRA.

George McC. Robson, M. A.

SIGNS—EQUATIONS—TRANSFORMATIONS—EXAMPLES.

IT IS well known that algebra enables us to solve a large number of problems which are difficult or impossible of solution by arithmetic; but it is not so generally known that algebra is a great deal easier and simpler than arithmetic. Before applying algebra to the solution of problems, we must become familiar with a few definitions and rules; these are very simple, and most of them are used in arithmetic as well as in algebra.

The sign of addition is $+$; it is read *plus*, and means that the numbers between which it stands are to be added together. The sign of subtraction is $-$; it is read *minus*, and means that the number before which



it is placed is to be subtracted. The sign of equality is $=$; it is read *is equal to*. A statement of equality between two quantities is called an *equation;* thus, $5 + 6 = 11$, and $12 - 4 = 8$ are equations. The ordinary balance will help us to understand how we are to treat equations. If we put 7 pounds and 3 pounds into one pan of a balance, and 10 pounds into the other pan, the beam will stand horizontal; this corresponds to the equation

$$7 + 3 = 10.$$

Adding 2 pounds to each pan, we get the equation

$$7 + 3 + 2 = 10 + 2.$$

Removing 4 pounds from each pan, we get the equation

$$7 + 3 + 2 - 4 = 10 + 2 - 4.$$

If we make the weight in one pan twice, thrice, or four times as great, we must also make the weight in the other pan twice, thrice, or four times as great. Or, if we reduce the weight in one pan to one-half, one-third, or one-fourth, we must also reduce the weight in the other pan in the same proportion.

Hence, we have the following important principles, which apply to any equation:

I. *The same quantity may be added to both sides.*

II. *The same quantity may be subtracted from both sides.*

III. *Both sides may be multiplied or divided by the same number.*

Performing any of these operations upon an equation is called *transforming* the equation. The reader must satisfy himself that none of these transformations destroys the equality of the two sides.

St. Andrew's cross $\times$ is used for the sign of multiplication; thus, $3 \times 4 = 12$. The sign of division is $\div$; thus, $12 \div 3 = 4$. But division is frequently indicated by writing the dividend over the divisor with a horizontal line between them; thus, $\frac{12}{3} = 4$.

In algebra, letters, as well as figures, are used to represent numbers; thus, x may represent a man's daily wages; and then $2 \times x$ will represent the daily wages of two men. If n represents a number of men, $n \times x$ will represent the daily wages of n men. The sign of multiplication is usually omitted for the sake of brevity; thus, $n \times x$ is written nx, $2 \times x$ is written $2x$, $a \times b \times c$ is written abc. The sign of multiplication, however, must not be omitted between figures; thus, 4×5 must not be written 45, because 45 means $40 + 5$ instead of 4×5. When a number consists of the product of two factors, each of the factors is called the *coefficient* of the other. Thus, if we regard $6ab$ as the product of 6 and ab, 6 is the coefficient of ab, and ab is the coefficient of 6; but, if we regard $6ab$ as the product of $6a$ and b, then $6a$ is the coefficient of b, and b is the coefficient of $6a$. In other words, coefficient means *cofactor*. When one of the factors is an arithmetical number, it is called the *numerical coefficient*.

In the expression $4x$, 4 is the coefficient of x and tells how many times x is to be taken; thus, $4x = x + x + x + x$. When no numerical coefficient is written, it is understood that the coefficient is 1; thus, $x = 1 \times x$.

We shall now apply these principles to the solution of a few very simple problems.

EXAMPLE 1.—A 60-foot pole is divided into two parts, so that one part is five times as long as the other; find the lengths of the parts.

SOLUTION.—Let x represent the length of the shorter part.

Then, Longer part $= 5x$;
Shorter part $= x$;

Sum of parts $= 6x = 60$.

Dividing both sides by 6 (Principle III), we get $x = 10$.

Therefore, $5x = 50$.

Hence, the parts are 10 ft. and 50 ft.

EXAMPLE 2.—Find a number such that when 17 is added to its double the sum will be 49.

SOLUTION.—Let x represent the required number; then $2x$ represents the double of the number.

Hence, $2x + 17 = 49$.

Subtracting 17 from both sides (Principle II), $2x = 49 - 17$;
or, $2x = 32$.

Dividing both sides by 2 (Principle III), $x = 16$.

EXAMPLE 3.—The sum of two numbers is 410, and their difference is 124; find the numbers.

SOLUTION.—Let x represent the smaller number. Then $x + 124$ will represent the greater. Thus we have

Greater $= x + 124$;
Smaller $= x$

Therefore, Sum $= 2x + 124 = 410$.

Subtracting 124 from both sides (Principle II), $2x = 410 - 124$;
or, $2x = 286$.

Dividing by 2 (Principle III), $x = 143$.

Hence, $x + 124 = 143 + 124 = 267$.

Therefore, the numbers are 143 and 267.

DISTINCTNESS.

G. Herbert Follows.

THE following story is told of Horace Greeley, founder of the "New York Tribune": There was upon his staff a young man who had been engaged to write articles upon certain topics of the day. One morning Greeley confronted him with the printer's proof of his latest effort, and after reading it aloud—it was an exceedingly florid bit of writing—asked him bluntly what it all meant. The young man was rather surprised at the question, for he had looked upon this effusion with considerable pride; however, he explained, and very clearly, too. "Well," said Greeley, "why didn't you *say* that? Go and write the article again, and this time say what you mean."

Greeley realized that, if a newspaper article is to make any lasting impression upon the mind of the reader, it must be something more than a mere perambulation of well sounding words.

We all know that, of two men who understand the same subject equally well, one may impress us as knowing much more about it than the other. We go to one, and he tells us in an unhesitating manner all that we wished to know, and we leave him feeling that we are in possession of valuable and interesting information. We go to the other and he starts out by saying that the subject is a very big one; then he attempts to tell us all he knows about it, "beginning at the very beginning"; takes up a great deal of time, and says many clever things, but sends us away bewildered, and ready to say, "Well, he *may* know all about it, but I don't think he does."

It is one thing to understand a subject yourself; quite another to make it plain to someone else. We at once *recognize* distinctness when it is present. To *define* it, however, is not so easy. A sentence may be very long, yet very distinct; on the other hand, it may be very short, yet so full of ambiguities as to mean nothing in particular. Brevity, then, is not necessarily an indication of distinctness.

Many very learned writers weaken what they say by trying to show that they know all about it, that they are not to be caught "napping." They use so many "howbeits," "notwithstandings," and "that-is-to-says," and make such frequent use of

expressions like "this must not be taken too literally," "of course there are many exceptions," and, "that is, generally speaking," that, by the time the reader gets through, he is rather inclined to think that the author himself is in doubt about the whole business.

Such writers are not sufficiently robust to do much good to anybody ; they lack courage —are too anxious not to say anything that is not absolutely true. Huxley hit them off to perfection when he said, "They make distinctions that destroy distinctness, until one thing means another and everything means nothing." The fact is, a simple, downright statement, though true only in part, is better than a complicated attempt to be exact. Just as in music a startling discord will greatly enhance the beauty of a succeeding harmony, so, in writing, an exaggeration of the exact truth will help the mind to appreciate what it is really the intention of the author to impress.

Lack of distinctness often indicates ignorance. If you don't understand a subject thoroughly yourself, you can hardly expect to explain it lucidly to others. You may make a very fair bluff, you may even succeed in *hiding* your ignorance for a time, but in the end your indistinctness will give you away. Lecturers, preachers, and public speakers in general are rather apt to forget this, and to attempt to create an impression by a multitude of words. Those who are familiar with Sir Walter Scott's "Guy Mannering" will remember the ludicrous attempts of Sir Robert Hazlewood, the pompous Scotch magistrate, to be impressive. Here is a passage from a conversation between him and the villain Gilbert Glossin :

"Yet even now I venture to conjecture that I shall adopt the solution or explanation of this riddle, enigma, or mystery, which you have in some degree thus started. Yes! revenge it must be—and, good Heaven! entertained by and against whom?—entertained, fostered, cherished, against young Hazlewood, of Hazlewood, and in part carried into effect, executed, and implemented, by the hand of Vanbeest Brown!"

And again, during the trial of Brown :

"And so, sir, you, sir, admit, sir, that it was your purpose, sir, and your intention, sir, and the real jet and object of your assault, sir, to disarm young Hazlewood, of Hazlewood, of his gun, sir, or his fowling-piece, or his fuzee, or whatever you please to call it, sir, upon the king's highway, sir?"

Dickens, in his "Pickwick Papers," depicts a somewhat similar character in George Nupkins, Esquire, chief magistrate of Ipswich. Sam Weller's opinion of this gentleman's oratorical powers is humorously expressed in a conversation with Mr. Muzzle, the magistrate's footman :

"'Ah,' said Sam, 'what a pleasant chap he is!'

"'Aint he?' replied Mr. Muzzle.

"'So much humor,' said Sam.

"'And such a man to speak,' said Mr. Muzzle. 'How his ideas do flow, don't they?'

"'Wonderful,' replied Sam ; 'they comes a pouring out, knocking each other's heads so fast, that they seems to stun one another ; you hardly know what he's arter, do you?'

"'That's the great merit of his style of speaking,' rejoined Mr. Muzzle."

Again, in "Bleak House," we find an excellent exponent of wordy ignorance in Mr. Chadband, whose particular weakness was "holding forth" with cowlike lightness after eating at some one else's expense. A few extracts from one of his full-stomach addresses will suffice :

"My friends, we have partaken in moderation" (which was certainly not the case so far as he was concerned) "of the comforts which have been provided for us. May this house live upon the fatness of the land ; may corn and wine be plentiful therein ; may it grow, may it thrive, may it prosper, may it advance, may it proceed, may it press forward! But, my friends, have we partaken of anything else? We have. My friends, of what else have we partaken? Of spiritual profit? Yes. From whence have we derived that spiritual profit? My young friend, stand forth. My young friend, you are to us a pearl, you are to us a diamond, you are to us a gem, you are to us a jewel. And why, my young friend?" (The boy he is apostrophizing says, "I don't know. I don't know nothink.") "My young friend, it is because you know nothing that you are to us a gem and jewel. For what are you, my young friend? Are you a beast of the field? No. A bird of the air? No. A fish of the sea or river? No. You are a human boy, my young friend, a human boy. O glorious to be a human boy! And why glorious, my young friend? Because you are capable of receiving the lessons of wisdom, because you are capable of profiting by this discourse which I now deliver for your good, because you are not a stick, or a staff, or a stock, or a stone, or a post, or a pillar.

O running stream of sparkling joy,
To be a soaring human boy!

"And do you cool yourself in that stream now, my young friend? No. Why do you not cool yourself in that stream now? Because you are in a state of darkness, because you are in a state of obscurity, because you are in a state of sinfulness, because you are in a state of bondage. My young friend, what *is* bondage? Let us, in a spirit of love, inquire."

But it is not to writers and public speakers alone that distinctness is of importance. It is a matter of *personal* importance to every ambitious man, for, if you do not *think* distinctly, your knowledge will be more or less shadowy and undefined. However limited in extent your knowledge may be, if it is distinct and thorough so far as it goes, it will be useful. Bear in mind that you can *never* know *all* about *any* subject, but do not ever doubt the truth of what you have once mastered, simply because you don't know all the rest of it. Remember that, though a knowledge of the multiplication table does not make you a "mathematician," it has a distinct and great value in itself, *if it is exact*. It is so with the rudiments of every science; indeed, the importance of a distinct knowledge of fundamental principles cannot be overestimated, and it is almost impossible to give up too much time to the study of them.

There are many ways in which distinctness may be cultivated. Talking, writing, and drawing are three of the best. Encourage discussions with those of your friends who are interested in the subjects you are studying. Write your knowledge down; or, if you wish to understand a machine, or device, or anything that can be illustrated, make freehand sketches of it and of all its parts. There are no better ways than these of finding out what you really know, or of cultivating the habit of distinctness.

SAILOR SUPERSTITIONS.

Ernest K. Roden.

Belief in the Supernatural—The Phantom Ship, the Mermaid, and the Sea Serpent. Equatorial Ceremonies—Sailor Songs.

THE deep-sea sailor, or Jack Tar as he is familiarly called, has, in common with the great majority of mankind, many little weaknesses. His good-natured love of sociability is too well known to need more than passing mention, and is such an amiable weakness that we are ever ready to forgive the little excesses to which it occasionally leads him. To be sure, he is poorer in pocket and sometimes considerably the worse in health after a protracted indulgence, but he is nothing like as bad as he used to be, and goes on improving.

The peculiar and interesting weakness that we wish to dwell upon here is Jack Tar's superstition. Many a stalwart sailor has had his bravery turned to cowardice by his belief in the supernatural. Of course, as the years roll on, and steam power is used instead of sails and wind, the sailor is influenced less and less by this inherited weakness, but there are still many old salts who are firm believers in the mermaid, the sea serpent, and the phantom ship. Among these creations of the mind, that of the phantom ship, or Flying Dutchman, is perhaps the best known, for it still affords the poet a theme for verse, and the author for romance, the reading of which has been the cause of many a schoolboy's staying at home in the evening, instead of indulging in his usual after-dark skylarking.

This phantom ship is said to be a double-decker, always seen to the windward with every bit of canvas set, veering and hauling, not in the water like any ordinary ship, but up among the clouds. Sometimes it touches the horizon; at other times it steers constantly towards the beholder, with the apparent intention of crossing the bow of his ship. The sight of this storm-tossed phantom ship is an omen of ill fortune to the luckless beholders, and doomed is the crew of the vessel whose bow is crossed by the Flying Dutchman. They never live to tell the tale. When a vessel and crew disappear and no trace of either is ever found, the common saying among sailors is that "The Flying Dutchman crossed her bow." The captain of this phantom ship is said, in a fit of rage, to have cursed the author of his being—to have defied the Almighty who governs the winds and the waves. Its crew are old sinners of the sea—thieves and

murderers—who, together with their wicked master, suffer and toil eternally, without rest, having little to eat and less to drink.

Believing, as he does, in phantom ships, the sailor has also a firm belief in ghosts. That dreadful specter, Adamaster, who haunts the white folds of the Devil's Tablecloth, which mantles the headland of the Cape of Good Hope, is much talked of in the forecastle. Its appearance in the twilight, hovering in cloud and mist, is a sign of coming disaster.

Minor superstitions on shipboard are numerous. A playful cat is a sure indication of an approaching storm; and an old forecastle tradition says that "a black cat carries a gale of wind in her tail." Hence, many ship cats of the somber hue are tailless, save a two-inch stub, left possibly for the purpose of identification. Clergymen and women are looked upon with disfavor on a ship, the former being considered unlucky because of their black gowns and their principal duty of consoling the dying and burying the dead, and also because the storm raiser, the Devil, is the parson's greatest antagonist and is likely to send hurricanes to destroy him. Women are looked upon in the forecastle as spellbinders, no human form being so much dreaded as the female brewer of hell-broth.

A dead body kept on board always brings ill luck, and it is the sailor's firm belief that a sick man cannot die until the tide begins to ebb. That freak of nature, St. Elmo's fire—an electrical discharge from the mastheads, etc.—is a solemn warning to the sailor. If, when playing about the yardarms and mastheads, it throws its pale spectral light full into anyone's face, it is to that person a sure sign of death.

Perhaps it is not surprising, however, that the sailor believes thus in supernatural agencies and warnings, when we remember that superstition is allowed to enter into the very timbers of the vessel before she is even launched. Thus, stolen wood is often mortised into the keel "to make the ship sail faster at night." A silver coin is placed under the top band of the mainmast to bring good luck; and woe unto the builder who fails to put it there before the vessel is launched. It is believed that, if during the driving of the first nail in the keel the first blow "draws fire," the ship is doomed to destruction on her maiden voyage. Ship bells are blessed to bring good fortune. If, through carelessness or ignorance, a mistake is made in the striking of bells, they are invariably struck back to break the spell, and the man who strikes nine bells is sure to come to grief unless he strikes one back.

On board Spanish vessels, sailors are often seen aloft beating away for dear life at the sheaves and pins of the blocks. They do this to drive the devil out of the gear. This act of incivility to his Satanic Majesty is the outcome of a certain disaster which happened to a Spanish "flying squadron," which, when surprised at a long occupied anchorage, was unable to set sail and engage the approaching enemy, because the pins and sheaves of the principal hoisting gears had rusted in their seatings. Beating the blocks was then resorted to. From a reliable source the writer is informed that this same beating of the blocks was performed by the Spanish sailors belonging to Admiral Cervera's squadron the night before leaving the harbor of Santiago to meet with destruction at the hands of Admiral Sampson's squadron. Presumably they did it from force of habit, as there are very few blocks to beat in modern men-of-war.

On Easter mornings, Roman Catholic sailors cockbill their yards, and hang that arch-traitor Judas in effigy to a yardarm. After hanging for an hour or so, the poor fellow is lowered to deck, and beaten and kicked unmercifully until nothing is left of him but dust.

Whistling on board a ship is against the proprieties of sea life. You can whistle in a calm as much as you please, as a lagging wind may be spurred on in consequence, but you must never indulge in that particular pastime after the ship is set going. If you do, the probability is that a gale will be sent your way instead of the gentle breeze you whistled for to fill your flapping sails. In a calm, the porpoise is looked upon as a good forecaster regarding the direction of the anxiously awaited breeze. It is said that a shoal of porpoises after having hovered in the vicinity of the becalmed vessel will depart in the direction of the coming wind. As a matter of fact, this is true to a certain degree. From personal experience and frequent observations, the writer knows that in the majority of cases they do depart against the wind. Another peculiar thing is that the skeleton of a porpoise when balanced in a horizontal position and hung up with a string will point with its head toward the approaching wind.

When a ship is deserted by rats, it is considered a bad omen. The desertion undoubtedly occurs for good and natural reasons.

The rat, like its arch-enemy the cat, likes to run about dry-footed, and will stick to a vessel only so long as there is plenty of food and comfortable quarters, and will surely desert when his field of operation becomes too wet, or, in other words, when the ship is leaky and unseaworthy.

Among the superstitions that still exist to materially influence the mind of the mariner, that which makes it unlucky to go to sea on a Friday is perhaps the most active. With few exceptions a captain will remain in port until Saturday, even though favorable winds are blowing, rather than set sail on a Friday. The origin of this superstition is said to be that Friday was the day upon which the Flying Dutchman left port, and no shipmaster cares to follow such an example, except when compelled to do so.

During an ocean voyage of any great length, the crossing of the equatorial line is considered an event of much importance, and is celebrated by a day of fun making at the expense of all those members of the crew who have never crossed the line before—such individuals being generally known on shipboard as *greenhorns*. It has been suggested by some writers that the origin of this fun making is of a superstitious nature; but this can hardly be true, the jokes that are played being of far too practical a character to suggest anything of a supernatural origin. Upon the occasion of the writer's crossing the line for the first time, he had what was to the onlookers an amusing experience. With a razor made of the very best hoop iron obtainable, and after his face had been lathered with soap containing at least ninety per cent. of coal tar, he was duly shaved according to the prevailing custom. This process fully and deliberately complied with, he was cordially invited by King Neptune to be seated near His Majesty, and the invitation, being a most unexpected honor, was promptly accepted. Instead, however, of enjoying a much needed rest, the seat suddenly gave way, and he was plunged backwards into a tank of water, upon the surface of which were floating the bodies of three rats, killed the day before by the ship's dog. Of such a nature generally are the ceremonies attending the crossing of the line nowadays in a large sailing vessel.

Songs, and songs only, are used by sailors during the performance of their work, and a good deal of superstition is connected with them. To hoist the anchor without song means a stormy voyage, and any sail spread in silence is of little or no use as a means to increase the speed of the vessel, and is likely to be taken in very soon after it is set. With few exceptions, these songs of the sea come from the forecastle, where they are manufactured by the sailor himself. The following specimens will serve to show that, however appropriate the sailor may think them, they possess little poetic sentiment.

Song of the Anchor.

Whisky makes a poor old man;
O whisky, whisky!
Johnny met me in the street.
Johnny asked me if I'd treat;
O whisky, whisky!
I said yes next time we'd meet;
O whisky, whisky for Johnny.

When hoisting topsails the favorite is:

A Yankee ship came down the river;
Blow, my bully boys, blow!
They keep an Irish mate on board her;
Blow, my bully boys, blow!
Do you know who is captain of her?
Blow, my bully boys, blow!
Jonathan Finks of South Caroliner;
Blow, my bully boys, blow!

Or this:

Haul the bowline—Kitty you're my darling.
Haul the bowline—bowline haul.

The origin of the sailor's superstition is doubtless to be found in the many uncontrollable phenomena of nature with which he has to deal; he has not the intelligence to account for them nor does he possess the indifference concerning them that governs the mind of the more preoccupied landsman. It is an outgrowth of the fear of the unknown and its grip on simple minds.

The uneducated landsman, unacquainted alike with metaphysics and biology, sees, like a child, a personality in every strange and ill defined object. A cloud like an angel may be an angel; a bit of crooked root resembling a human being may be a human being turned into wood. The man is puzzled by it, and at last makes up his mind that it is alive, avoids it, and trembles at the mere thought of it.

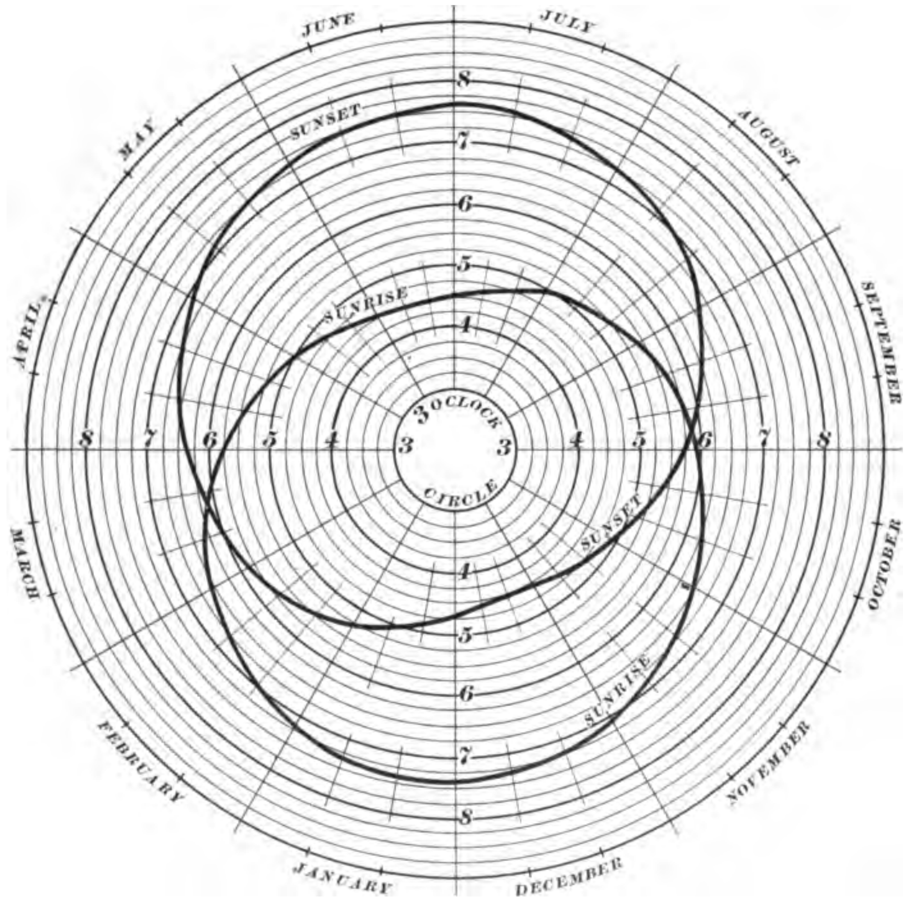
It is the same with the sailor. To him a thing that apparently defies explanation is supernatural. He is not afraid of the tempest with which he has to battle, but he fears the unknown that causes the tempest. There are times when tempests become frenzied, when the heavens are attacked with a sort of delirium, and the firmament raves and hurls its lightnings blindly. Nothing can possibly be more terrible than these wild outbursts of Nature's rage; more hideous moments can scarcely be imagined. Such occurrences as these deeply impress the simple-minded sailor, and often open within him a wide berth for superstition.

A CHART FOR SUNRISE AND SUNSET.

Anonymous.

THE accompanying chart, by which, at a glance, the time of sunrise or of sunset for any day in the year can be quickly ascertained, will, I think, interest readers of THE MECHANIC ARTS MAGAZINE. Those who understand the use of diagrams in general will appreciate its handiness, while an explanation will serve a double purpose with those who are ignorant of the usefulness of such diagrams, for it will teach them not only how to use this particular chart, but will add to their stock of intelligence touching one of the simplest methods of representing to the eye the rate and the manner of change of a varying quantity.

We will begin by *using* the chart. Suppose we wish to know at what time the sun will rise on the 10th of May. We first find the slice of the chart marked *May.* Now the line dividing the April slice from the May slice is the last day of April. The 10th of May will, therefore, be one-third of the way over the May slice—reckoning 30 days to the month. The sunrise curve is marked *Sunrise;* bear this curve in mind. Concentric circles struck from the center of the chart are marked *3*, *4*, *5*, *6*, *7*, and *8*; these represent hours; the space between every adjacent pair, as between the 4-o'clock circle and the 5-o'clock circle, is divided into four equal parts, each small space representing a quarter of an hour, or 15 minutes. That is all there



is to the chart itself. On the 10th of May, that is, one-third of the way over the May slice, a radial line will intersect the *Sunrise* curve at a point just beyond the third quarter past the 4-o'clock circle, indicating that on that day the sun will rise at about 4.47 A. M. The short radial lines every third part of a slice help the reader to locate any intermediate date.

Charts in general are quite as simple as this, and many are much simpler. Easy, isn't it?

PEAUCELLIER'S MOTION.

Anonymous.

METHOD OF DEMONSTRATING ITS MOTION BY DIRECT GEOMETRY.

THE excellent article, "How to Draw a Straight Line," by Mr. Goodenough, interested me very much. The following is what I consider to be an exceedingly simple proof of Peaucellier's straight-line motion, which, being directly geometrical, will perhaps be of interest to readers of THE MECHANIC ARTS MAGAZINE.

Let $B\,C\,D\,E$ be a rhombus; $A\,C = A\,E$, $A\,M = M\,B$. $A\,M$ remains in place; all other lines are pivoted at their extremities, so that they move freely. This is the Peaucellier machine.

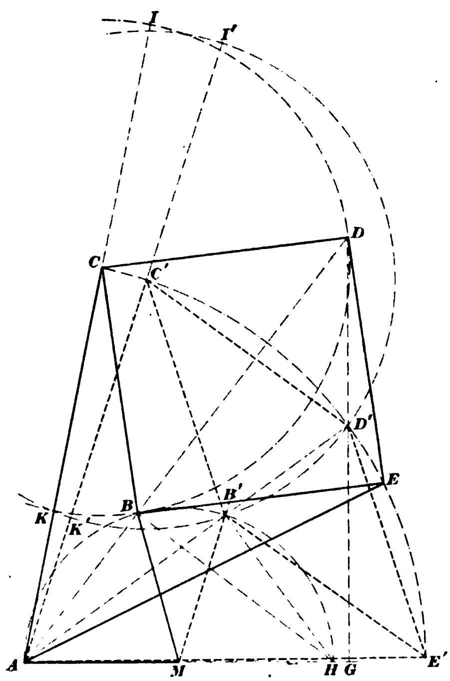
Produce $A\,M$ indefinitely. With center M and radius $A\,M\,(= M\,B)$, describe semicircle $A\,B\,H$. From D let fall a perpendicular upon $A\,H$, or $A\,H$ produced. Draw $A\,D$ and $B\,H$. Since $A\,C = A\,E$, and since $B\,C\,D\,E$ is equilateral, $A\,D$ will pass through B. (a)

Triangles $A\,D\,G$ and $A\,H\,B$ are similar, for the angle A is common, and each contains a right angle. Then, $A\,B : A\,G = A\,H : A\,D$, or, $A\,B \times A\,D = A\,G \times A\,H$. (β)

Move B along the arc $A\,H$ to any point, as B'. The point C will move to C', E to E', D to D'. (The construction of the new position of the rhombus is simple, for B' is equidistant from C' and E', and they are equidistant from A, and D' is also equidistant from C' and E'.) With C and C' as centers and radius $C\,B$, describe circles C and C'. Produce $A\,C$ to I, and $A\,C'$ to I'. $A\,I = A\,I'$, and $A\,K = A\,K'$. For the former are each equal to $A\,C + B\,C$, and the latter are each equal to $A\,C - B\,C$. (γ)

In circle C, $A\,I \times A\,K = A\,D \times A\,B$, and in circle C', $A\,I' \times A\,K' = A\,D' \times A\,B'$. Then (γ), $A\,D \times A\,B = A\,D' \times A\,B' =$ (β) $A\,G \times A\,H$. That is to say, whatever position the rhombus may occupy, any rectangle $A\,B \times A\,D = A\,G \times A\,H =$ a constant quantity.

From the relation $A\,D' \times A\,B' = A\,G \times A\,H$, we have the proportion $A\,D' : A\,H = A\,G : A\,B'$, and hence the triangles $A\,D'\,G$ and $A\,B'\,H$ are similar. But $A\,B'\,H$ is a right angle, being inscribed in a semicircle; therefore, the homologous angle $A\,G\,D'$ is a



right angle, and D' is in the perpendicular $D\,G$.

It is evident that this reasoning applies, whether the foot of the perpendicular fall within the semicircle, at the extremity H of the diameter, or upon the diameter produced.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

TRANSFORMED AFRICA.

PART I.

TWO maps of Africa lie before me. One is just fifty years old; the other bears the date 1898. What have they in common? There are the same outlines, the blunt rounded contours which contrast so strangely with the sharp projections and indentations of the other continents; there are the same river estuaries, and a few of the same names appear in the north and east. The old map is Africa of the dark ages, whose heart is an unknown blank. The continent here portrayed was the seat of one of the most ancient civilizations of the world, yet in her relations to the modern progressive human race she is sunk in sleep. The hand of the nineteenth century has hardly touched her.

On this map of 1848 there is a little patch of British red at the south, indicating Cape Colony—originally settled by the Dutch, but ceded to the British in the early part of the century. Two or three red and purple spots on the northwest coast mark British and French trading settlements. On the Mediterranean a purple strip, with undefined southern limits, shows where the French have been established in Algeria for twenty years. Portugal lays claim, by right of fifteenth- and sixteenth-century discoveries, to parts of the eastern and western coast lines, but the regions lying behind her possessions remain a sealed book, except when occasional glimpses are revealed through the horrible medium of the slave trade. In the interior are the Mountains of the Moon, the supposed source of the Nile; a wide territory bears the names of Ethiopia and the Great Desert; and unexplored regions abandoned apparently to wandering Bushmen fill up the remaining space.

But the day approached when the long sleep of ages was to be broken. British, French, and German explorers pushed their way steadily, slowly, towards the heart of the African continent, and roused the sluggish senses, bringing her into contact with the atmosphere of action which lay around her. Year by year new facts were revealed and were recorded on the maps of the day, first tentatively, then definitely. Newly discovered natural features fell into place; the Mountains of the Moon disappeared; the supposedly barren interior was shown to contain some of the finest lakes in the world; the Kongo, heretofore unexplored, proved to be a wonderful river system with a thousand affluents, watering a fertile country in the very heart of this tropical region.

The changes which were made in the map in consequence of the discoveries of explorers, seemed to be rapid—our fathers still looked half incredulously at the new lakes and rivers, not sure that they represented established facts, when, presto! the scene changed! Africa was suddenly swept into the zone of European politics, and as if by magic her aspect was completely transformed. The atlas of 1898 depicts her as clad in a coat of many colors, each one representing the authority of some European power, and the boundary lines of each section have been defined by international agreement. "In the eighteenth century the white man took Africans from Africa; in the nineteenth century he has taken Africa from the Africans"; is a statement as true as it is epigrammatic. And strange to say, the partition of this continent has not led to war between the various powers which have divided the spoil, and entered into the heritage of the black races. The pen has taken the place of the sword, and the rules of the game which were agreed on when the scramble for Africa began, have been observed with moderate fairness by the participants.

Half a century ago, only two European powers manifested any active interest in Africa—Great Britain and France. Cape Colony was of much importance to the former as a half-way house to India and Australia, and its boundaries were gradually enlarged by conquest, by treaty, and by measures incidental to the repression of the slave trade, among the Dutch and African neighbors on her borders. The importance of trade on the Niger had also begun to be recognized. In the north, France showed eagerness and foresight in her efforts to extend her empire, and was steadily pushing-

her way in that region. Two men may be held responsible for the whirlwind which changed a gradual growth into a mad rush for unoccupied territory—Henry M. Stanley and Prince Bismarck, in their respective capacities as explorer and statesman. Stanley revealed to the world the Kongo River region, and it was not in human nature to neglect the opportunity of seizing so valuable a possession for modern civilization. King Leopold of Belgium was the first in the field, and created what is known as the Kongo Free State. As he is its sovereign, it is to all intents and purposes a Belgian colony, to which he contributes a large sum annually from his private fortune.

The Berlin Conference, a meeting of the Powers interested in Africa, took place in 1884, for the arrangment of details connected with the boundaries of the Kongo Free State. But other matters also came before it for consideration. In the early part of the same year, Prince Bismarck's plans for the creation of a German colonial empire had taken shape, and the German flag had been raised over a portion of the west coast of Africa, to the north of Cape Colony. It was certain that Germany's example in the occupation of unclaimed territory would be copied by others; and at the Berlin Conference conditions were agreed on under which annexations would be recognized by the Powers.

At this point there began what has been described as "the modern rush of the civilized on the uncivilized world"; and in a very few years the map of Africa appeared in its new dress. The British red spread north from Cape Colony to the southern point of Lake Tanganyika, then, after a break of a few hundred miles, extended to the southern frontier of Egypt and the Sudan, which is under a virtual British protectorate. Only two sections of the coast line of East Africa belong to Great Britain; the rest has fallen to the share of Portugal, Germany, and Italy. On the west coast, the Niger River region and three smaller sections are also colored red. France is the predominant power in the north, where her flag flies over vast territories, much of which, however, is infertile and sparsely populated. She has a fine province on the north of the Kongo, a settlement near the mouth of the Red Sea, and the great island of Madagascar. She controls one-fourth of the area of Africa; and Great Britain, if her occupation of Egypt be called a protectorate, controls another fourth part.

Germany is established on the east coast between the great lakes and the Indian Ocean; on the west coast, north of Cape Colony; and at two other places east and west respectively of the Niger River. By right of discovery, Portugal claims large sections of the east and the west coast, for which as yet she has done very little in the way of development; and Italy nominally occupies two strips of the eastern coast, shorn of much of their width in consequence of her recent war with Abyssinia. This ancient kingdom still survives. Morocco on the northwest coast is also independent, and Tripoli is a Turkish province. Two small Dutch republics in the South, the Transvaal and the Orange Free State, strive to isolate themselves from modern ideas of commerce and government, but their probable fate is absorption in a British South-African Confederation. The negro republic, Liberia, on the west coast, has existed for fifty years as an independent government. The center of the continent is occupied by the Kongo Free State, under the sovereignty of King Leopold of the Belgians; and there remains unappropriated only a section, largely desert, lying between the Egyptian Sudan and French West Africa, of which France will probably gain the larger portion.

These great tracts of country in Africa are necessarily controlled in very varying degrees by the Powers to which they have been allotted. In some, little or no authority is exercised. Such lands are said to be merely within the "sphere of influence" of the specified Power. This phrase, now fully adopted into the diplomatic vocabulary, is a creation of the Berlin conference. Within a given "sphere" other Powers are not expected to intrude, either to found independent trading stations, or to make treaties with native chiefs. There must be a certain degree of effective occupation, perhaps a fortified post here and there; and the protecting Power must see that trading caravans can pass in safety, and that slave raiding is checked. By degrees it is expected that the resources of the country will be developed, and meanwhile the nominal protector is to have a free hand as against European competitors. When full possession has been taken, as in the colonies, the machinery of order and government is established, and the inhabitants, native and foreign, are subject to law.

The doctrine of the *hinterland* was also a development of the Berlin conference, and the word has been adopted to the exclusion

of the more familiar English expression, "back country." The coast line is naturally the first point of occupation, and it is obviously for the benefit of all concerned that each Power should be left free within certain limits, and that there should be no interference with her communications in the rear. Inevitably, when two Powers are advancing towards each other, a time comes when their *hinterlands* may overlap, and difficulties arise in the settlement of limits. This has recently been the case between Great Britain and France in West Africa and in the Sudan. Agreements made between any two or three Powers are not considered to be binding on a fourth if the natural development of her territory brings her in contact with a disputed frontier, and it will probably be long before the delimitations of the various "spheres of influence" are all arranged in detail.

Meanwhile Africa has become a political appendage of Europe, and as such will take her place in the history of a new century.

STEPPING STONES IN THE ART OF COOKING.

Mrs. Henry Esmond.

Step I: Cooking in Water.

BEFORE entering into the subject of this, our first step in the art of cooking, it may be well to consider why food has to be cooked at all, and why it is not eaten raw—that is, in its natural state. Well, without attempting to guess when man first discovered that certain food materials were improved by being submitted to the action of the heat of a fire, suffice it to say that certain food materials are cooked because it is known that the process makes them more palatable and more digestible.

Now, there is more than one way of cooking foods. There are, indeed, many ways; but, broadly speaking, they all have the same main object, namely, to convert some material into wholesome food by subjecting it to the action of heat. Whether the heat shall be applied *directly* or through some such heat-distributing medium as *water*, depends upon the nature of the food material to be cooked. You will at once see that there is a vast difference between putting a piece of raw beef into boiling water and holding it close to the live flame of a hot fire. In this lesson we will confine ourselves to "cooking in water."

Perhaps it has never occurred to you that water itself is really cooked when you boil it. In a *chemical* sense, this is hardly true, because heat causes no change whatever in *chemically pure* water, except the physical change of expanding it and converting it into steam. But when we speak of water, we mean the water supplied to us through the water mains for drinking and for cooking purposes; and this water is *never* pure, though it may be perfectly wholesome. The water, then, contains foreign matter, either in solution or in suspension; sometimes it contains disease germs, or microbes, as they are usually termed; but, whatever the foreign matter, boiling cooks it, and any microbes that may be present are thus destroyed and rendered harmless. In this sense, then, when you *boil* water, you really *cook* it.

For cooking purposes, water should always be used as soon as it is boiled; it should never be allowed to stand in the kettle for any length of time afterwards. The temperature at which water boils depends on the foreign matter it contains. Pure fresh water boils at 212° Fahrenheit; salt water does not boil until it is heated to 224° F. The addition, then, of salt to fresh water increases the temperature of the food cooked in it. Before water reaches the boiling point, it *simmers;* the temperature is then about 185° F.

Now, there are three distinct ways of cooking in water:

1. The food material may be plunged into boiling water, and left there until cooked—the water always boiling.
2. The material may be covered with cold water, and the temperature gradually raised to simmering point, keeping it there until the material is cooked.
3. The material may be covered with cold water, and raised quickly to the boiling point; then, after a certain length of time, allowed to simmer until cooked.

In order to make each method clear and comprehensible, we will take a piece of raw meat, cut it into three portions, and experiment with each, taking the three methods in the order given above.

On plunging the first piece into boiling water, we shall see that its bright red color changes quickly to a pale gray. This is due to the albumen on the surface of the meat being coagulated, or hardened, by the heat of the boiling water. This seals the pores on the surface of the meat, and prevents the escape of the meat juices. When the meat is done, you will find that the water is scarcely discolored, which shows that all the juice is sealed up in the meat.

Take, now, the second portion, and cut it into small pieces; cover them with cold water, and stand the vessel on the back of the stove, and allow it to come slowly to the simmering point—but no hotter. Let this process of simmering continue for 2 hours, and you will find that all the juices that were in the meat are now in the water, and that the meat itself is white and tasteless—that, in fact, all the goodness is drawn out of it, and that nothing is left but tough fibers.

Put the third piece of meat into cold water, and raise quickly to the boiling point. Keep it boiling for 5 minutes, then let it simmer until the meat is done. Now you will find that, before the water boiled, a sufficient quantity of juice was extracted from the meat to flavor the water, but that enough was left in the meat to keep it juicy and palatable. Thus, by letting the water boil for a few minutes, the pores were sealed before too much of the meat juices had escaped; but you will also find that the long-continued simmering has rendered the meat very tender and toothsome.

Now, what do we learn from the experiments? That very tender meat may with advantage be cooked by method 1; that method 2 cooks the meat to fiber, producing *extract* of the meat cooked; that method 3 may be employed with advantage where the meat to be cooked is fresh and tough, as it renders it tender and enhances the flavor; that this method takes a long time, certainly, but that cheap meat may thus be made palatable.

There are many dried fruits and vegetables, such as dried apples, prunes, lentils, peas, beans, and corn, that have to be soaked for hours in cold water before cooking, in order that they may absorb the amount of water they contained before they were dried. If these dried foods are plunged at once into boiling water, they remain hard and tough, however long they are cooked.

All cereals and grains—oatmeal, wheat, hominy, oats, rice, etc.—should be cooked in boiling water, as cold water draws the starch out of them. If they are put on the fire in cold water, sufficient starch will be drawn out before the boiling point is reached to make the water whitish and sticky; and when cooked, instead of being light and flaky, the mass will be sticky and impalatable. These foods should be cooked in twice their volume of water; that is, for every ½ cup of grain, allow 1 cup of boiling water. When cooked, the water should be completely absorbed, and the grain should be separate and flaky. As cereals are nowadays prepared for the market, they take from 20 to 30 minutes to cook. Hominy, whole oats, and rice take 1 hour.

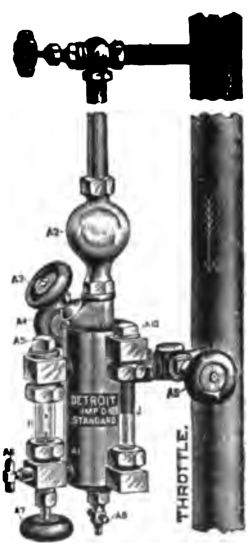
In cooking vegetables, where it is desired to retain the shape, add a little salt to the water; this hardens the outside just enough to prevent falling. All vegetables contain what is known as vegetable albumen, and under the three methods of cooking in water already described, they behave much as meat does. For instance, if potatoes are plunged into boiling water, the surface albumen is hardened; then the heat of cooking causes the starch to swell and burst the little cells in the potatoes and also the coating formed by the coagulated albumen on the outside, the result being what we call a mealy potato. If, instead of this, the potatoes are put into cold water, and gradually raised to the boiling point, the starch will be drawn out, much as the juice was drawn from the meat, and the potatoes will become saturated with water and unfit to eat when cooked.

Beans, rice, and lentils—in fact, any very starchy dried vegetable—should be left in cold water for some hours before cooking; this soaking swells the starch grains to their original size, and for all practical purposes makes the vegetable fresh again.

TRADE NOTES

AN IMPROVED SIGHT-FEED LUBRICATOR.

THE ANNEXED cut illustrates the "Detroit" improved standard lubricator, and method of attachment. This lubricator, made by The Detroit Lubricator Company, Detroit, Michigan, is intended especially for the better classes of engines, and represents the highest development in its line. It is convenient, durable, and reliable. Among the improvements enumerated by the manufacturers are the following: (1) The support arm is in two parts. The part containing the globe valve is first screwed into the steam pipe, and the lubricator is then coupled to it. This makes the attachment very easy, and, on account of the globe valve, the lubricator proper can be removed at any time, for repairs or otherwise, without letting down steam. (2) The heating passage from the upper sight-feed arm to the support arm passes directly through the body of the lubricator, and, being always filled with steam, it keeps the oil constantly warm and in a thoroughly liquid condition. This lubricator is particularly well adapted for feeding heavy oils. (3) There is a drain stem under the sight-feed glass, which allows the water to be drained out and the glass cleaned at any time. (4) The oil is poured directly into the body in the pint and larger sizes, doing away with the necessity of a vent. (5) The sight-feed and gauge glasses are inserted through the upper arms. (6) The sight-feed glass and the valve regulating the feed are on the opposite side from the steam pipe.



THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

A GRADUATE'S magazine — "The Technology Review"—has just been issued by the recently organized Association of Class Secretaries. It is an octavo volume of 140 pages, attractive in appearance, and of the best workmanship. The cover, designed by Hapgood and printed on army brown paper, is very handsome. The first number contains the Announcement; a photograph with biographical sketch of President Crafts; articles on "The Function of the Laboratory," by Professor Silas W. Holman, and on the "Pierce Building," by Professor Eleazer R. Homer, the architect; reprints in facsimile of early Institute documents and letters—all in the first and more general half. The latter half, seventy pages, is given to news of the Institute, of the undergraduate and graduate classes. Plans are shown of the several floors of the new Pierce Building, of the first floor of the Rogers Building as now altered, and of the dynamo house. There are two half-tone inserts and two line drawings, one by Gelett Burgess. An excellent review of Professor Holman's recent book on "Matter, Energy, Force, and Work" is given by Dr. Goodwin.

CAR-WHEEL TESTS.

IN CONSIDERING the question of safety in railroad traveling, the matter of rolling-stock efficiency occurs at once to the mind. And among the various items that come under this head, car-wheel failures make up about 33 per cent., or one-third of the whole. Little wonder, then, that customers, when ordering these parts, insist on strict tests. Usually, after the wheels have been inspected ready for shipment, one of them is chosen at random out of every group of a hundred. This is then tested by falling weights, the number of blows to be withstood varying with the size and weight of the wheel. If the test wheel breaks under less than the prescribed number of blows, a second wheel is chosen. If this one proves satisfactory, the inspector may pass the remainder,

or he may chose another one and test that also. In these tests the wheel is laid flat on its face, supported on three points not more than 5 inches wide, and the weight then dropped upon its hub. Sometimes it is laid flat on a circular support placed under the outer rim, so as to support it all around its outer edge, the weight being then dropped upon the body near the rim.

The New York Car Wheel Works, of Buffalo, N. Y., have sent us a catalogue in which are described and illustrated various tests made by The P. H. Griffin Machine Works of Buffalo, of their special quality wheels. The accompanying half-tone illustrates a severe test applied to wheels made to specifications of the Belgian State Railway. The weight is dropped from varying heights, beginning at 19 inches and increasing by increments of 19 inches. The wheel has to stand five such blows without breaking into pieces, to insure the acceptance of the group it represents. Another severe test for wheels made under the German State Railway specifications is to lay the wheel flat upon its face and put conical pieces into the hub (bored tapering for the purpose), a steel wedge fitting into these pieces. A weight of 475 pounds is then dropped upon the top of the wedge, which thus exercises a severe bursting action on the wheel. It must be gratifying to the general public to know that such pains are taken to insure safety and freedom from defects in so important an item as the wheels of the vehicles they entrust their lives to.

THE ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR 1896.

A SMALL part of this report is devoted to the proceedings of the Board of Regents and the annual report of the secretary of the Institution, Mr. S. P. Langley, in which appears a short account of Mr. Langley's successful experiments in mechanical flight. The chief interest in the Report centers, however, in the "General Appendix," which is made up of a series of memoirs, or abstracts, consisting for the most part of addresses and lectures delivered before scientific societies. This appendix is intended to be a record of scientific progress in astronomy, physics, chemistry, geology, and other sciences. While the individual papers are of particular value to scientists, most of them are of a more or less popular character, and will prove of interest to the general reader as well. We give a brief synopsis of some of the leading papers. "The Problems of Astronomy," by Simon Newcomb; the problems mentioned are the extent of the universe, the duration of the universe in time, the nature of the comets, and the variation of latitudes. Dr. Leo. Koenigsberger's lecture entitled, "The Investigation of Helmholtz on the Fundamental Principles of Mathematics and Mechanics," is replete

with suggestions to mathematicians. In "Physical Phenomena of the Upper Regions of the Atmosphere," Prof. Cornu explains some perplexing points concerning the motions of the atmosphere, and mechanically illustrates the action of the cyclone and waterspout. Prof. Thurston in his article, "The Animal as a Prime Mover," states that the efficiency of the animal machine—that is, the ratio of the external work of the animal to the dynamic equivalent of the energy latent in the food supply—is about 20 per cent. He in the first place discusses at some length the relative value of different foods and diets, and afterwards the distribution of the energy supplied by the food. A specially readable paper is "The War with the Microbes," by E. A. de Schweinitz. It is a historical review of the investigation of the disease-producing germs and the methods employed to check their ravages. The paper closes with a short discussion of the useful bacteria and their influence on food products, such as milk, butter, wine, etc. Other papers contained in the appendix are:

"New Researches on Liquid Air," Prof. Dewar.

"The Processes of Life Revealed by the Microscope," S. H. Gage.

"The Rarer Metals and Their Alloys," W. C. Roberts-Austin.

"Utilization of Niagara," T. C. Martin.

THE RAYFILTER.

One of the most glaring defects of the average landscape or marine photograph is its blank, expressionless sky. Few users of the camera take the trouble to make two exposures of a subject in order to have its sky on a separate plate that can be "printed" in, after the landscape foreground is printed; and yet that is what we all had to do before the introduction of the "Rayfilter" as an adjunct to the photographic outfit. The Rayfilter consists of two disks of finely polished plate glass mounted in a brass ring, and so separated as to form a cell, which can be filled with any colored liquid. This cell fits over the lens tube of the camera, and acts as a color screen, filtering out those rays of light which act so rapidly upon the plate as to overexpose it in one part before another part has received any impression whatever.

For ordinary purposes the cell is filled with a solution of bichromate of potassium, which is of a deep reddish-yellow color and effectually screens from the plate those extremely actinic rays of light which, though they make snap-shot photography possible, do it at the expense of detail in the foreground and clouds in the sky. The Rayfilter increases the necessary exposure of a fast plate from five to seventy-five times what would be required without it. But which do you prefer—a picture like the first photograph, which was taken in $\frac{1}{15}$ of a second, or a picture like the "Rayfiltergraph," exposed

for 5 seconds? The two figures here shown illustrate the whole story in a nutshell, and show conclusively not only what the Rayfilter *can* do but what it *does* do.

In landscape and marine studies, in snow scenes, and in architectural views with strong sunlight, the Rayfilter fills a long-felt want that no other device has ever before been able to fill. They are manufactured by the Bausch and Lomb Optical Co., of Rochester, N. Y., who will gladly furnish any additional information required as to the details of this very useful little instrument.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches containing questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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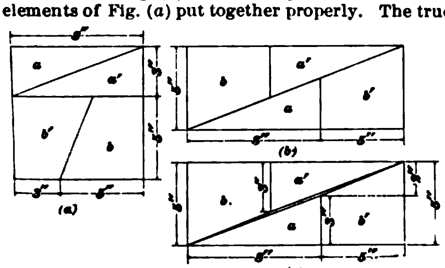
(1) At (*a*) in sketch, we have an 8-inch square, area of which is, of course, 64 square inches. Cutting it upon the lines shown and fitting the pieces together as shown at (*b*), we get a figure 13″ × 5″, giving 65 square inches. Where does the extra square inch come from? P. H. P., New York, N. Y.

ANS.—Your Fig. (*b*) does not represent the various elements of Fig. (*a*) put together properly. The true



(a) (b) (c)

state of affairs is shown in Fig. (*c*), in which the extra square inch is readily seen to be due to the attenuated parallelogram along the diagonal of the rectangle. This question and answer was published in HOME STUDY MAGAZINE, October, 1897. During the past few weeks, however, the same question has been sent in by several of our readers. It would seem almost unnecessary to state that no area can be either increased or decreased by merely cutting it into pieces. The total area of the pieces, however arranged, must be the same as that of the original figure. There cannot possibly be any exception to this.

* * *

(2) (*a*) I have some tinware that is badly worn. Can you tell me how to retin it? (*b*) What is the process of nickel-plating or silver-plating iron, steel, or brass, and what are the materials used? (*c*) Many of the parts of my bicycle are nickel-plated; in several places the nickel is worn off. Before renickeling these parts, will it be necessary to remove all the old nickel, and if so, how is this done?

R. A. W., San Francisco, Cal.

ANS.—(*a*) In most cases it will cost more to retin old tinware than to make new ware; but it can be retinned by experts in such work. The process of retinning is substantially the same for all metals. The surfaces to be tinned are first cleaned with acid, and then melted tin applied, by dipping, pouring on, or sprinkling on; while hot, the tin is wiped smooth with tow. (*b*) Your questions on electroplating are too comprehensive for this department. In HOME STUDY FOR ELECTRICAL WORKERS, June, 1898, there is an article devoted to the subject. We can refer you to "Modern Electroplating," by J. H. Van Horne, price $2.00, for sale by The Technical Supply Co., Scranton, Pa. (*c*) All the old nickel should be removed before replating. This is done by fine emery, glued on a leather polishing wheel.

* * *

(3) In a double-cylinder 6-horsepower gasoline engine, in which the pistons uncover the exhaust, and the inlet ports are one after the other (Sintz style), and are connected to the carbureter in the tank (Monitor style) by a 1¼-inch pipe, and with 1¼-inch exhaust pipe from each engine; the flame "carries down" and explodes the charge in the crank chamber. (*a*) Is it usual to put a flame arrester between the crank chamber and the piston chamber to prevent this? If not, what is the matter with it? The engine will run all right for a few minutes, and then seems to choke up and usually explodes in the crank chamber, and stops. (*b*) What size exhaust pipe should be used in a 5-horsepower two-cycle gasoline engine? Also, what size of suction pipe from tank? (*c*) At what depth under the gasoline in the carbureter should the end of the air-inlet pipe be, to give best results? G. A. S., Cornwall.

ANS.—(*a*) The trouble is probably due to an insufficient supply of gasoline. It is not customary to place a valve between the crank chamber and the cylinder, but we believe it has been done with good results. Make sure that everything about the crank chamber is gas-tight, and when an explosion occurs in the chamber turn on more gasoline. (*b*) Make the area of the exhaust pipe 12 per cent. of that of the piston; use ½-inch suction pipe. (*c*) At least 3 inches.

* * *

(4) (*a*) What is the usual method employed for testing the bearing power of soils for the foundations of large buildings? (*b*) What is quarry water? (*c*) What kinds of stone are used for damp courses? (*d*) What is the difference between a caisson and a crib? (*e*) What books would you recommend to one who wishes to fit himself for the position of superintendent of construction?

W. C. H., Hammond, Ind.

ANS.—(*a*) Small areas of the soil are loaded with pig iron, the loads being allowed to remain for a considerable time—say one or two weeks—and the settlement carefully observed with a leveling instrument. Test piles are sometimes driven and the bearing power of the soil estimated from the penetration under a given blow. (*b*) Quarry water is a term applied to the moisture contained in stone newly taken from the quarry, and which gradually evaporates when exposed to the air. (*c*) No particular kind of stone is used for this purpose, so far as we are aware. Damp courses—that is, courses intended to prevent the absorption of ground water by capillary attraction—are commonly laid in asphalt, the asphalt covering the face of the stone, and extending

intact through the joint. See HOME STUDY FOR THE BUILDING TRADES, January, 1898. (*d*) A caisson is water-tight; and, in order to prevent the water from entering the bottom through the material in which it is being sunk, it is commonly provided with an air lock during the process of sinking; see HOME STUDY MAGAZINE, October, 1897, article entitled "Pneumatic-Caisson Foundations." A crib is merely a timber structure sunk in the water, and filled with stone or other material. (*e*) "Elementary Building Construction," by E. J. Burrell, price 80 cents; "Building Superintendence, 'Part I, Masonry,' 'Part II, Carpentry,'" by F. E. Kidder, price $1.00; "Building Superintendence," by J. M. Clark, price $3.00; "Safe Building," by L. DeC. Berg, price $5.00. These books are for sale by The Technical Supply Co., Scranton, Pa.

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(5) I have a fan motor for an 18-volt circuit, on which are 6 lamps. The motor makes 2,000 revolutions per minute; the resistance in the armature is about 1 ohm. I want to wind this for a 220-volt circuit, the speed to remain about the same. What size wire must I use, and will it be necessary to change the wire on the armature?

L. A. K., Roxbury, Mass.

ANS.—If we understand you correctly, you have a fan motor in series with six 16-candlepower lamps, on a 110-volt circuit. This will allow about 2.6 amperes to flow through the motor. To use it on a 220-volt circuit, you would need to connect in series with it twelve 16-candlepower 110-volt lamps. If the insulation of the motor is good enough to withstand an E. M. F. of 220 volts, your motor will operate as well under the latter conditions as under the former.

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(6) (*a*) How is the striking force of a steam hammer figured out? (*b*) What is the force of the blow that an ordinary man can strike with a 30-pound sledge hammer? (*c*) What force will it take to break a cast-steel roll, 7 feet between necks, and 22 inches in diameter at the middle, which is also the weakest part? Show how this is worked out. (*d*) Let me have the titles of any books you know of treating upon the above subjects.

R. B., Youngstown, Ohio.

ANS.—Let

W = weight of hammer in pounds;

v = velocity of hammer in feet per second, when it encounters the nail or other resistance;

s = distance which the nail, the pile, or whatever is struck, is driven;

F = striking force.

The energy of the hammer when it encounters the resistance is $\frac{W v^2}{64.32}$; and the work done, which must be equal to this stored energy, is the product of the striking force F, and the distance s, through which this force is exerted; hence,

$$\frac{W v^2}{64.32} = F s, \text{ or } F = \frac{W v^2}{64.32 s}.$$

(*b*) It is apparent that the striking force depends entirely on the character of the resistance which the hammer encounters, and not on the effort of the man; thus, if the hammer strikes a large mass of metal, the distance s will necessarily be small, and F, the force, will be very great; if, on the other hand, the hammer should be driven into some yielding substance, the distance s would be comparatively large, and the force F correspondingly small. (*c*) The breaking load may be determined from the following formula:

$$M = .0982\ D^3\ S,$$

where M = bending moment of the load;

D = diameter of the roll;

S = the modulus of rupture.

In this case the bending moment is $\frac{1}{4}\ W l$, where W is the load, and l is the length of the roll between supports. Since $l = 84$ inches, $M = \frac{1}{4} \times 84\ W = 21\ W = .0982\ D^3\ S$. The modulus of rupture depends on the quality of the steel, and is quite variable. Probably for the quality of steel in question, the value is not far from 100,000 pounds per square inch. Using this value,

$$W = \frac{.0982 \times 22 \times 100,000}{21} = 4,979,200 \text{ lb.},$$

or, practically, 5 million pounds. This load is supposed to be gradually applied; if the load is suddenly applied, that is, if it is dropped upon the roll, it would need to be but one-half of the gradually applied load, or $2\frac{1}{2}$ million pounds. (*d*) We know of no book treating exclusively on these subjects. "The Mechanics of Engineering," by Church, contains considerable information on these and allied subjects, and is in other respects a good book to have in one's possession; it is, however, quite mathematical.

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(7) (*a*) Why can a planet's satellites be seen more distinctly with the aid of a mirror than when viewed directly with the naked eye? (*b*) Is the sun at the present time undergoing changes similar to those that the earth went through during its formation? (*c*) If an electric current is directed into a pool of water, is it possible for a person to be injured by placing the hand in the water?

A. A. G., Clyde, Ohio.

ANS.—(*a*) It is not possible to see a planet's satellites, either with the naked eye or with the aid of a mirror. If we view a planet, say Jupiter, in a mirror, two small bright spots are seen, one on each side of the image of the planet; these bright spots are sometimes mistaken for the images of the planet's satellites, but this is simply an optical illusion. If the planet is examined through a small telescope, it will be seen that the position of its satellites does not at all correspond to the position of the bright spots in the mirror. (*b*) Yes: the sun is now undergoing changes similar to those through which the earth passed in former ages. (*c*) The conditions liable to exist in such a case make it possible to answer this question both in the affirmative and in the negative. If the pool of water has an unlined excavation for its containing basin, then the path directly to the ground would be of such low resistance as to make the alternative shunt circuit through the body of infinitely higher resistance in comparison. If one wire in a grounded circuit is led into a pool of water which is contained in a concrete- or stone-lined basin, it is possible to offer a path of comparatively low resistance to earth through the body. Should a high difference of potential exist between the two wires in the circuit, powerful physiological effects might ensue.

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(8) I have been solving some of the examples in the early numbers of HOME STUDY MAGAZINE, Answers to Inquiries department, and am somewhat disappointed in not obtaining the answers given. For instance, in answer to question No. 64, July, 1896, issue, how do you get the 70 pounds for the M. E. P. "on the steam end of the pump referred to the area of the low-pressure cylinder"? I have similar trouble with Question No. 2 in the February, 1898, issue. Please explain these fully.

F. F. H., New York, N. Y.

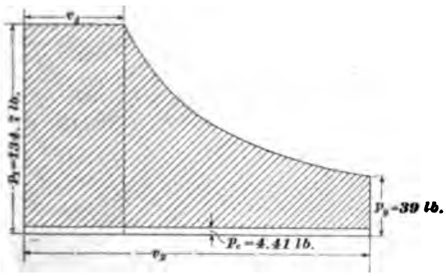
ANS.—The first of the questions you refer to is as follows:

"Will a single compound-condensing pump, of the dimensions given below, discharge 500 gallons per minute against a head of 275 pounds per square inch (including friction in the water pipes)? If so, what is the margin of power over resistance? Dimensions of the pump are: high-pressure cylinder, 14 inches in diameter; low-pressure cylinder, 26 inches in diameter; plunger, 10 inches in diameter. The gauge

pressure at the high-pressure cylinder is 120 pounds. The vacuum is 21 inches. All pipes are in good condition and of ample area."

The answer given is as follows:

"The solution you offered was not correct, since the pressures in the cylinder made no allowance for expansion in the low-pressure cylinder, such as actually takes place. The mean effective pressure on the steam end of the pump, referred to the area of the low-pressure cylinder, after allowing a small per cent. for losses in friction in passage from the high-pressure cylinder to the condenser, is 70 pounds. This, multiplied by the area of the low-pressure piston (530.9 sq. in.) and the piston speed in feet per minute (153.2), and the result divided by 33,000, gives the I. H. P. of the pump, which is found to be 172.5. The piston speed is determined from the formula $S = \frac{30.636\,G}{d^2}$, when 25 per cent. of the theoretical discharge is added to allow for slip. In this formula, d = diameter of plunger in inches; G = discharge in gallons per minute, and S = plunger (or piston) speed in feet per minute. Substituting the values given, $S = \frac{30.636 \times 500}{10^2} = 153.2$ feet per minute, nearly. The H. P. required to discharge 500 gallons per minute against a pressure of 275 pounds (or a head of



$275 \times 2.304 = 633.6$ feet) is equal to the weight of 500 gallons multiplied by the height to which it is raised and the result divided by 33,000; that is, H. P. required $= \frac{500 \times 8.355 \times 633.6}{33{,}000} = 80.208$. Owing to slip, leaks, etc., this is but perhaps 75 per cent. of H. P. required. Then, $\frac{80.208}{.75} = 107$ = actual H. P. required, allowing for losses. And $\frac{172.5 - 107.0}{107} =$ 61 per cent. (nearly), or the per cent. of power available above that required to raise 500 gallons against a pressure of 275 pounds. Now, the average total static pressure exerted by both steam cylinders is 37,163 pounds. The static pressure of the water is 21,599 pounds, leaving over 72 per cent. margin for pressure."

Assume to start with that the pressure in the high-pressure cylinder is the full boiler pressure, 120 pounds, and neglect the losses due to condensation, resistance of valves and passages, etc. In reality, there must be a space between the two cylinders, but theoretically this will not affect the M. E. P., and it will be assumed that the steam passes directly from the high-pressure into the low-pressure cylinder. Let v_1 and v_2 denote respectively the volume of the high-pressure and the low-pressure cylinders. Since there is no cut-off in either cylinder, there is at the beginning of the stroke a volume v_1 of steam at boiler pressure (134.7 pounds per square inch, absolute) acting against the low-pressure piston; at the end of the stroke this steam fills the low-pressure cylinder, and has therefore a volume v_2; and, according to Mariotte's law, which we will assume to hold true for the expansion of steam, the pressure of the steam (absolute) is

$$134.7 \times \frac{v_1}{v_2} = 134.7 \times \frac{14^2}{26^2} = 39 \text{ lb. per sq. in.},$$

since the volumes v_1 and v_2 are proportional to the squares of the diameters. Now, the theoretical work of the engine is the same as if the steam had entered the low-pressure cylinder at boiler pressure, and had expanded to the terminal pressure, 39 pounds; and the diagram for the theoretical work is that shown in the figure. The well known formula for the work is

$$\begin{aligned}\text{Work} &= p_1 v_1 + p_1 v_1 \log_e \frac{p_1}{p_2} - p_c v_2;\\ &= p_2 v_2 + p_2 v_2 \log_e \frac{p_1}{p_2} - p_c v_2;\\ &= v_2 \left\{ p_2 \left(1 + \log_e \frac{p_1}{p_2}\right) - p_c \right\}.\end{aligned}$$

Since the work is the product of the mean pressure and volume v_2, it follows that the theoretical M. E. P. is given by the expression $p_2\left(1 + \log_e \frac{p_1}{p_2}\right) - p_c$, where p_c is the condenser pressure, namely, $14.7 \times \frac{30 - 21}{30} =$ 4.41 pounds per square inch. Substituting,

$$\text{M. E. P.} = 39\left(1 + \log_e \frac{134.7}{39}\right) - 4.41 =$$

83 lb. per sq. in., nearly.

This M. E. P. cannot, of course, be realized in practice, on account of the various losses to which the steam is subjected during its passage through the cylinders. If we assume 85 per cent. as the ratio of the actual to the theoretical M. E. P. (this ratio is rather high for this type of engine), the actual M. E. P. is $83 \times .85 = 70.55$ pounds per square inch. The second question and answer you refer to are as follows:

"(*a*) I have a duplex compound-condensing pump with steam cylinders 14 inches and 26 inches and water cylinders 13 inches in diameter, all with a stroke of 18 inches. The pump works against an average water pressure of 60 pounds per square inch, with an average suction of 3 feet. The steam pressure at the pump is 35 pounds, at the boiler 80 pounds. What will be the horsepower when the pump makes, respectively, 10, 20, and 40 revolutions per minute? (*b*) With a water pressure of 100 pounds there is a pressure of 60 pounds in the steam chest. What is the horsepower for these pressures?"

"ANS.—(*a*) Computing the horsepower from the pressure against which the pump works, and allowing 20 per cent. of the total power for frictional losses, the pump requires 18 horsepower to drive it at 10 revolutions per minute, 36 horsepower at 20 revolutions, and 72 horsepower at 40 revolutions. (*b*) Computing the power in the same way as before, the horsepowers will be: for 10 revolutions 30 horsepower, for 20 revolutions 60 horsepower, and for 40 revolutions 120 horsepower."

The results are given in round numbers, but are practically correct. The total pressure against which the pump piston works is $60 + (.43 \times 3) = 61.3$ pounds per square inch. The area of the 13-inch cylinder is 132.73 square inches. Using the formula H. P. $= \frac{PLAN}{33{,}000}$, we have, for 10 revolutions per minute,

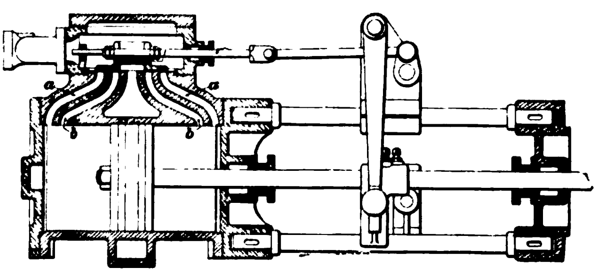
$$\text{H. P.} = \frac{61.3 \times \frac{18}{12} \times 132.73 \times 2 \times 10}{33{,}000} = 7.4 \text{ nearly.}$$

For two cylinders, the horsepower is $7.4 \times 2 = 14.8$. The answer should read "allowing 20 per cent. of the *net* horsepower," instead of "20 per cent. of the *total* horsepower." Adding 20 per cent., the total horsepower is 14.8 H. P. $\times 1.20 = 17.76$ H. P., or, in round numbers, 18 H. P. The other answers follow directly from this.

(9) (*a*) In order to face up the end of a shaft in a lathe a side tool has to be used. To face both ends it is necessary to have two tools—a right-hand and a left-hand tool. What I want to know is, which of the two is the right-hand tool. Is it the one that has the cutting edge on the right-hand side, or is it the one that faces the right-hand end of the shaft? (*b*) Is there any such thing as an "*O G*" bend that is used in mechanics? (*c*) If a fish weighs 1 pound in air and it is placed in 10 pounds of water, what will be the weight of the two together? (*d*) Is the actual weight of a vessel equal to its displacement? (*e*) I notice that in the steam cylinders of some pumps there are four steam ports, two at each end of the cylinder, the exhaust port being in the middle, as usual. What are the two extra live-steam ports for? I think the ports have communication with each other at each end of cylinder. (*f*) Is there such a thing as a left-hand engine?

J. P. S., Frackville, Pa.

ANS.—(*a*) The right-side tool is the one used for facing the right-hand end of the shaft. (*b*) An "*O G*" (commonly spelled *ogee*) bend is one having the form of an ogee curve, which may be described as two curves combined so as to curve in opposite directions—in other words, a reverse curve. (*c*) 11 pounds. (*d*) See HOME STUDY MAGAZINE, November, 1898, and December, 1898, Answers to Inquiries, Nos. 470 and 503. (*e*) The accompanying figure, which shows one of the steam cylinders of a Worthington duplex pump, shows the arrangement of ports about which you inquire. In a direct-acting steam pump, the valve has neither outside nor inside lap, and consequently steam follows the piston at full pressure, and, if no special provision were made, there would be no compression at the end of the stroke to prevent the piston from striking the cylinder heads. Referring to the figure, the two ports *a*, *a* are the ports which admit live steam to the cylinder, while ports *b*, *b* serve to lead the exhaust from the cylinder to the usual exhaust port. When the piston nears either end of its stroke, it covers the port *b* of that end, thus preventing the escape of steam through the exhaust; the steam remaining in the end of the cylinder after *b* is covered is compressed and acts as a cushion, which prevents the piston from striking the cylinder head. In the larger sizes of pumps a hole is drilled in the partition between the ports *a* and *b*: this hole is provided with a valve, which can be given sufficient opening to allow as much steam to escape from *a* into *b*, after *b* is covered by the piston, as will allow the piston to complete its stroke. The amount of the opening to be given to this valve depends on the pressure against which the pump is working and the speed at which it runs. If the pressure is high and the pump runs slowly, a larger opening is demanded than when the opposite conditions prevail. (*f*) By "a left-hand engine" is generally meant one which, when looked at from the cylinder end, has the crank on the left-hand end of the shaft, in which case the crank-shaft and pillow-block are at the right of the engine bed.



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(10) I am trying to fit myself for a position as draftsman in an architect's office. Will you kindly give me the name and price of a good book on architecture—one dealing with churches, cathedrals, and also opera houses? I want the book as a help to me in making designs. E. N. H., Marseline, Missouri.

ANS.—No one book will give you the information you require to fit yourself for a position as architectural draftsman. A regular and systematic course of study would be the best thing we could recommend. Architectural books are usually very expensive, but the following few are comparatively cheap: "History of Architecture," by Fergusson, $7.50; "History of Architecture," by Fletcher, $4.50; "History of Architecture," by Hamlin, $2.00; Gwilt's Encyclopædia of Architecture," $17.50. All of these may be obtained from The Technical Supply Co., Scranton, Pa. Gwilt's Encyclopædia is the only complete treatise on theoretical and practical architecture in the English language, but its methods, though valuable, are rather antiquated.

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(11) In a boiler 30 inches in diameter by 10 feet long in which there are twenty-two 3-inch tubes, (*a*) what area of heating surface should there be? (*b*) What will be the horsepower? (*c*) The distance from the top of the tubes to the crown of the boiler is 8 inches. Will 2 inches of water above the tubes be sufficient? (*d*) How much water will the boiler contain, if as in (*c*)? (*e*) What grate area should this boiler have? (*f*) How many cubic inches are there in a 5-inch pipe 10 feet long? (*g*) What is the outside area of such a pipe? J. S., North Adams, Mass.

ANS.—(*a*) 108 square feet. (*b*) Not more than 8 horsepower. (*c*) Yes, if you take care to keep the water-line constant. The available steam room in your boiler is small, and on opening the steam valve the glass is likely to show a higher level than there really is in the boiler. It would therefore be better to keep the level at least 3 inches above top of tubes by the glass. (*d*) With 2 inches of water over top of tubes, 31 cubic feet; with 3 inches of water, 33 cubic feet. (*e*) About 4 square feet. (*f*) A so-called 5-inch pipe (actual inside diameter 5.045 inches) 10 feet long contains 2,398.8 cubic inches. (*g*) Although by "the outside area of a pipe" is generally meant the area of a circle having a diameter equal to the outside diameter of the pipe, we presume that you wish to know the area of the outside surface of the pipe. Here are both: outside area, 24.299 square inches; area of outside surface, 2,097 square inches.

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(12) Kindly publish in your next issue a full description of how to lay a railroad track.

L. G., Exeter, N. H.

ANS.—We do not answer questions of this character, as the answer would require more space than can be afforded in these columns.

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(13) (*a*) What is the horsepower of a Day type gas engine of the following dimensions: three cylinders 3 inches in diameter, 3½-inch stroke, when making 500 revolutions per minute? (*b*) What is the pressure at the moment of explosion? (*c*) How can the pressure of gasoline be raised before being admitted into the cylinder? (*d*) What should be the size of the inlet and the exhaust ports for the above Day engine? (*e*) What would be the horsepower of the engine described in HOME STUDY MAGAZINE, August, 1898, Answers to Inquires, No. 326, if it were made to explode every revolution? (*f*) Show how you figured out the horsepower of the above engine. (*g*) Give the formula by which to figure the horsepower of a two-cycle gas engine.

F. R. B., San Francisco, Cal.

ANS.—(*a*) 3.5 to 5 horsepower. (*b*) About 180 pounds.

(c) By means of a pump. (d) Inlet port 7.5 square inches, exhaust port 10 square inches. (e) Twice that given in the answer. The horsepowers given in this answer should have been $\frac{1}{50}$ at 750 revolutions per minute, and $\frac{1}{35}$ at 1,000 revolutions per minute. A two-cycle engine gives twice the horsepower of a four-cycle engine of the same dimensions and running at the same speed. (f and g) The formula for a two-cycle engine is as follows:

$$\text{H. P.} = \frac{D^2 \times L \times R}{14{,}000},$$

where D = diameter of cylinder in inches;
L = length of stroke in inches;
R = revolutions per minute;
H. P. = average horsepower delivered by the engine.

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(14) (a) What are the formulas used for figuring the sizes of the inlet and the exhaust ports of two-cycle gas engines? (b) When designing a gas engine, how is the number of revolutions per minute decided upon, and what prevents the engine from running at some other speed? There seems to me no reason why every variation of load should not cause a corresponding variation of speed. Q. U. S., Boston, Mass.

ANS.—(a) Make the area of the inlet port 12 per cent., and the area of the exhaust port 16 per cent., of that of the cylinder. (b) The following formula, the use of which requires a knowledge of logarithms, represents the average American practice in this regard:

Let R = number of revolutions per minute;
H = nominal or catalogue horsepower of the engine.

Then, for a four-cycle engine,

$$R = \frac{350}{H^{.21}};$$

and, for a two-cycle engine,

$$R = \frac{405}{H^{.21}}.$$

The nominal horsepower is two-thirds of what the engine will develop when working at its fullest capacity, as when using natural gas or gasoline and giving an explosion at every revolution, or at every other revolution if it is a four-cycle engine. The engine is prevented from running at some other speed by a governor.

***

(15) What is the best book you know of on marine engineering? I want one that treats very fully upon condensing beam engines, such as are used on the Sound steamers. F. E. D., Brooklyn, N. Y.

ANS.—To the best of our knowledge there is no book in the market that devotes space to a thorough description of the condensing beam engine. A short description of the general features may be found in Appleton's "Encyclopædia of Applied Mechanics." A good book on general marine engineering is Seaton's "Manual of Marine Engineering," price, \$6. It can be obtained of The Technical Supply Co., Scranton, Pa.

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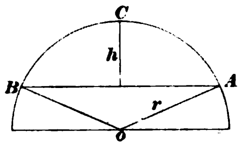
(16) (a) What are the methods of obtaining time, latitude, and azimuth from the heavenly bodies? (b) How are the stresses in the various members of a trussed bridge calculated? (c) It is said that ordinary glass can be cut to any required shape with an ordinary pair of scissors if the cutting is done under water—that is, if the glass is held under water. Is this so, and why? W. A. J., Auckland, New Zealand.

ANS.—(a) The description of the several methods employed for finding time, latitude, and azimuth would fill a volume, and consequently cannot be given in these columns. We would advise you to consult some work on navigation, such as "The Elements of Navigation," by W. J. Henderson, price \$1. For sale by The Technical Supply Co., Scranton, Pa. (b) By applying the principle of moments. They are also determined by constructing graphical diagrams based upon the conditions of static equilibrium. It would be impossible to describe either process in detail here. (c) We do not know, but suggest that you try the experiment yourself.

***

(17) Please show how a semicircle can be bisected by a line parallel to the diameter. Give geometrical and also algebraic proof.
J. R. B., Fredericksburg, Va.

ANS.—Let the number of degrees in the angle $A\,o\,B$ be denoted by n, and let the area of the segment $A\,o\,B$ be denoted by A. Then the area of the segment $A\,o\,B$ is given by the formula (1)



$$A = \frac{r^2}{2}\left\{\frac{\pi n}{180} - \sin n^\circ\right\},$$

where π is the ratio of the circumference of a circle to its radius. The area of the whole circle is πr^2. Therefore, we have

$$\frac{r^2}{2}\left\{\frac{\pi n}{180} - \sin n^\circ\right\} = \tfrac{1}{4}\pi r^2.$$

This equation can be solved only by trial; solving it in this way, we get angle $A\,o\,B = 132^\circ\,20'\,47\tfrac{1}{4}''$. From this value of the angle $A\,o\,B$, we get $h = .5960272 \times r$. Another way of solving this problem is as follows: From the exact formula (1) we can derive the approximate formula

$$A = \tfrac{2}{3} h^2 \sqrt{\frac{2r}{h} - .608};$$

hence, we have

$$\tfrac{2}{3} h^2 \sqrt{\frac{2r}{h} - .608} = \tfrac{1}{4}\pi r^2.$$

Solving this equation by Horner's method, we get $h = .596 \times r$. We could obtain the value of h to a greater number of decimal places by Horner's method; but, since the formula is only approximate, it is useless to go beyond the third decimal place.

***

(18) I have a dynamo for nickel-plating, and I cannot get any current from it. It has been in use a long while, and I have thought that perhaps the magnets have lost their strength. Is this likely, and how could I recharge them? I have a battery of 3 George Gray cells to run 10 gallons of nickel solution, but the articles take the nickel very slowly. I must tell you that I am green at the nickel-plating business, so that any information that you can give, or any book you can recommend me to study will be appreciated. A. L. K., Delaware.

ANS.—A shunt-wound generator is the best style for electro-plating. It is not possible for the field magnets of such a machine to lose their strength, except when the field circuit is broken. The battery that you use is either not of sufficient current output or else your plating solution is not correctly prepared. You can receive expert advice in this matter by writing to The Zucken, Leavitt & Loeb Co., New York, N. Y., or to Max Meyer, 121st St. and 2nd Ave., New York, N. Y. The former publish a book entitled "Practical Plating and Polishing," a copy of which is given to their patrons.

***

(19) In an ordinary gravity battery, the copper plates become heavily plated with copper, and the zincs are eaten up. (a) Of what is the sediment found at the bottom of these batteries composed? (b) What is its commercial value? (c) What is the market value of red oxide of copper, black powdered oxide, and black granulated oxide?
J. W. K., Chariton, Ia.

ANS.—(a) When the conditions given above prevail, very little of the sediment will be precipitated. This latter phenomenon occurs most prominently

when the cell is left in open circuit, thereby allowing the two solutions to diffuse with facility. Upon diffusion, the atom of copper in the molecule of copper sulphate is displaced by the atom of zinc in the zinc sulphate. The copper so displaced is deposited in a black spongy mass upon the surface of the zinc, or is precipitated to the bottom of the cell as battery "mud." The deposit on the zinc plate converts the cell, in a measure, into one with two copper surfaces. A small proportion of this mud can be attributed to impurities in the zinc, which fall to the bottom of the cell. (*b*) The commercial value of this sediment is from about 9 to 11 cents a pound. (*c*) Red oxide of copper: granulated, 13 to 16 cents a pound; precipitated, 40 cents a pound. Black oxide of copper: granulated, 13 to 20 cents a pound; precipitated, 40 cents a pound.

***

(20) What is (*a*) the method of cultivation of the peppermint plant? (*b*) the process of refining peppermint oil? (*c*) the kind of still used? (*d*) the estimated amount of oil produced per acre? (*e*) the market value per gallon? (*f*) the total amount distilled per annum in the United States?
T. Q. P., Detroit, Mich.

ANS.—There is an exhaustive article on this subject in Encyc. Britt., 9th Edit., under "Peppermint." You may also obtain reliable information on the subject from the Department of Agriculture, Washington, D. C.

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(21) What is the principle of action in the air chambers on a modern double-acting pump?
T. F. S., Olyphant, Pa.

ANS.—During a part of its stroke the pump discharges water faster than the average flow through the discharge pipe; the extra water then enters the air chamber, and compresses the air therein; at other parts of the stroke the pump discharges less water than the average flow through the discharge pipe; the air in the air chamber then expands, and forces out the extra water. The flow through the discharge pipe is thus kept nearly uniform, and the pump is preserved from severe jars and shocks.

***

(22) Can you tell me why the flush and back air connections on earthenware closets crack off when they are connected with rubber elbows? I find that, after they have been in use for a short time, no matter what the quality, they break.
H. C. T., Piermont, N. Y.

ANS.—A first-class horn, attached to a first-class bowl in a first-class manner, will not break off when a flexible rubber elbow joins a flush pipe to the horn. When horns do break off, the defect lies in the connection between the horn and the bowl; in plain words, the break indicates cheaply made goods, and such horns are simply stuck on and glazed over.

***

(23) Kindly give me the titles, authors, and prices of books relating to the following subjects: (*a*) steam pumps; (*b*) geometric drawing; (*c*) steam-engine design; (*d*) problems in steam engineering.
C. U. F., Moline, Ill.

ANS.—(*a*) "Pumping Machinery," by William M. Barr, price, $5.00; "The Mechanics of Pumping Machinery," by Dr. Julius Weisbach and Prof. Gustav Herrmann, translated by Karl P. Dahlstrom, M. E., price, $3.75; "A Practical Handbook on Pump Construction," by Philip R. Bjorling, price, $1.50. (*b*) "Drafting Instruments and Operations," by Prof. S. Edward Warren, price, $1.25; "Elements of Machine Construction and Drawing," by Prof. S. Edward Warren, 2 vols., price, $7.50; "Mechanical Drawing," by Prof. Chas. W. MacCord, in two parts—Part I, "Progressive Exercises," price, $2.50; Part II, "Practical Hints for Draftsmen," price, $2.50—the two parts complete in one volume, price, $4.00; "Mechanical Drawing," by Wm. Minifie, price, $4.00; "Elements of Mechanical Drawing," by Gardner C. Anthony, price, $1.50; "Mechanical Graphics," by Geo. Halliday, price, $2.00. (*c*) "Steam-Engine Design," by Jay M. Whitham, price, $6.00; "The Relative Proportions of Steam Engines," by William Dennis Marks, price, $3.00; "Design of a High-Speed Steam Engine," by Prof. J. F. Klein, price, $6.00; "The Steam Engine," by Arthur Rigg, price, $10.00. (*d*) "Constructive Steam Engineering," by J. M. Whitham, price, $10.00; "The Mechanical Engineering of Power Plants," by Prof. F. R. Hutton, price, $5.00; "Experimental Engineering," by Prof. R. C. Carpenter, price, $6.00; "A Manual of Marine Engineering," by A. E. Seaton, price, $6.00. Any of the above books will be sent, postage paid, by The Technical Supply Co., Scranton, Pa., on receipt of price named.

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(24) (*a*) Please explain the Edison series arc dynamo. How does it generate high or low voltage? (*b*) When designing a dynamo, how many lines of force per square inch is generally figured on? (*c*) What is the principle of the gyroscope top?
E. A. A., Granite Falls, Minn.

ANS.—(*a*) We have never heard of the Edison series arc dynamo. Kindly send us a further descripton of the machine you refer to. (*b*) General practice dictates the following: Density in teeth of slotted armature, 100,000 lines of force per square inch. Density in magnet core, cast iron, 40,000 to 50,000 lines per square inch; cast-steel and wrought-iron forgings, 95,000 to 105,000 lines per square inch. Density in yoke, cast iron, 30,000 lines per square inch; cast steel, 75,000 lines per square inch; wrought-iron forgings, 85,000 lines per square inch. Density in armature core, drum armatures, 85,000 to 90,000 lines per square inch; ring armatures, 100,000 to 110,000 lines per square inch. Where the percentage of compounding is in excess of normal requirements, it is best to use slightly lower values than those given above, so as not to approach saturation at large loads. (*c*) See HOME STUDY MAGAZINE, August, 1897, Answers to Inquiries, No. 275.

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(25) I have some posts to put down in a heavy clay soil; they are to form the foundation for a building. On putting them into the ground in the ordinary manner, I find that they heaved up with sufficient force to lift the building with them. How can I prevent this, and what is the cause of such peculiar behavior? The posts are heaved up clear out of the ground.
C. A. Y., Toronto, Canada.

ANS.—Having only the scanty information given in your inquiry, we are unable to form an opinion of what *did* cause the heaving, but can only state what *might* have caused it. If the post holes were not dug below the frost line—which varies from 3 to 6 feet below the surface, according to the section of the country—it is more than possible that the upheaval was caused by the action of frost on the large quantity of water which clay always contains. On this account, and also because of its liability of being squeezed out from under a wall, clay is the most troublesome to build on of all ordinary soils. There are other possible causes for the heaving, such as the erection of a very heavy building on an adjacent lot, or pile driving operations being carried on close by; but all things considered, we believe the one given to be the most probable.

***

(26) I have an alternating-current generator built by The General Electric Co.; it is type A. S., Class 20, 180 K. W. (*a*) Kindly explain how the compound on this machine is connected up. What I mean is,

explain the connection between the armature, commutator, and receiving rings. (*b*) What is the use of the triangular coil at the commutator end of the armature? (*c*) In an alternating-current generator where the currents in the compound are generated by independent coils in the armature, what causes the current in these coils to increase as the load increases and compensate for loss on the line?

L. J. N., Kalamazoo, Mich.

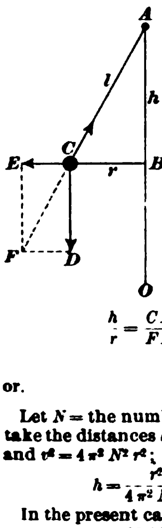
ANS.—(*a*) The commutator serves to rectify the current induced in the secondary of a transformer whose primary coil is in series with the load. This rectified current is led through windings, called the *series field winding*, which is placed similarly to that of a direct-current compound machine. (*b*) This current is a shunt on the series field, and by altering its length the degree of overcompounding or undercompounding can be varied. (*c*) A rise in load causes an increased current in the circuit of the series field winding, thereby maintaining the voltage of the machine.

***

(27) What is the height of a simple pendulum governor whose arms are 1 inch long, when making 50 revolutions per minute?

O. S. P., Lisbon, Ohio.

ANS.—In the accompanying figure, AC is the length l of the governor arm, AB is the height h, and $BC = r$ is the distance of the ball from the axis AO. In this position, the ball is acted upon by three forces: one, the weight w of the ball represented by CD; a second, the centrifugal force represented by CE and whose magnitude is $\frac{w v^2}{r g}$, where v is the velocity of the ball in feet per second; third, the pull of the arm l, which must be equal and opposite to the resultant CF of the two forces first mentioned. It is evident that the triangles ABC and CDF are similar; hence,



$$\frac{h}{r} = \frac{CD}{FD} = \frac{CD}{CE} = \frac{w}{\frac{w v^2}{r g}} = \frac{r g}{v^2},$$

or.

$$h = \frac{r^2 g}{v^2}$$

Let N = the number of revolutions per *second*, and take the distances l, h, and r in *feet*. Then, $v = 2 \pi N r$, and $v^2 = 4 \pi^2 N^2 r^2$; hence,

$$h = \frac{r^2 g}{4 \pi^2 N^2 r^2} \text{ feet} = \frac{g}{4 \pi^2 N^2} \text{ feet}.$$

In the present case $N = \frac{50}{60}$; therefore,

$$h = \frac{32.16}{4 \times (3.1416)^2 \times (\frac{50}{60})^2} \text{ feet} = 1.2 \text{ feet nearly.}$$

This discussion shows that the height h is independent of the *length* of the arm, and depends only on the speed of the governor. Since h must be 1.2 feet, or over 14 inches, it follows that, for the governor to be operative at the given speed, the arms must be at least 14 inches long; therefore, with arms 1 inch long there is no action whatever, and the question proposed is meaningless. The governor will become operative when the height h is just equal to the length l; that is, when h = 1 inch = $\frac{1}{12}$ foot. This gives

$$\frac{1}{12} = \frac{g}{4 \pi^2 N^2}, \text{ or } N^2 = \frac{3 g}{\pi^2} = \frac{3 \times 32.16}{(3.1416)^2};$$

whence $N = \frac{\sqrt{96.48}}{3.1416} = 3.13$ revolutions per second, or about 188 revolutions per minute.

***

(28) (*a*) How many amperes may I expect from the following storage battery? Two plates 4½ inches long by 2 inches wide; the thickness I cannot give, as the plates are corrugated, but they are about ¼ inch apart. (*b*) I want a spark coil for igniting coal gas, to weigh not more than 2 pounds. I have directions for making coils weighing from 5 to 8 pounds, but these are too heavy.

S. T., Houston, Texas.

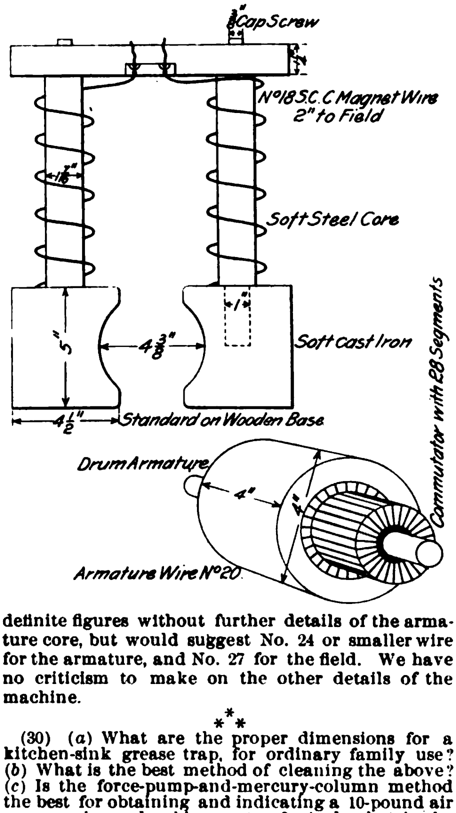
ANS.—(*a*) The capacity of a storage cell is generally given in ampere hours, not amperes alone. For well constructed cells, allow 4.5 ampere hours per pound of plate. (*b*) Make a core of iron wire 6 inches long and 1 inch in diameter. Fit a wooden flange ½ inch thick to either end. Wrap the core with two layers of tape, or some other insulator of like thickness, and then wind three-quarters of a pound of No. 16 B. & S. double cotton-covered copper wire evenly on the core. This coil will weigh no more than 2 pounds, and will give satisfaction if a current of sufficient strength is used.

***

(29) I wish to know how to build a direct-current dynamo. I have built one, but it is not a success; it is on the Edison plan; the enclosed sketch will give you an idea of its proportions. What I want to know is how to proportion and design such a machine.

L. J. B., Nebraska City, Neb.

ANS.—It appears that the armature wire and the field wire are each too small. We cannot give



definite figures without further details of the armature core, but would suggest No. 24 or smaller wire for the armature, and No. 27 for the field. We have no criticism to make on the other details of the machine.

***

(30) (*a*) What are the proper dimensions for a kitchen-sink grease trap, for ordinary family use? (*b*) What is the best method of cleaning the above? (*c*) Is the force-pump-and-mercury-column method the best for obtaining and indicating a 10-pound air pressure in a plumbing system? And what is the cost of outfit? (*d*) Are spring-gauge pumps desirable for the above purpose? (*e*) Is it possible to so adjust this latter apparatus that it gives incorrect readings?

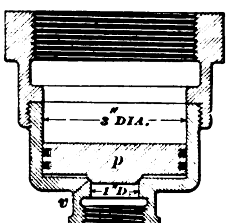
A. B. C.

ANS.—(*a*) The dimensions of a grease trap for a kitchen sink in a private family depend upon the size of the family and the kind of cooking that is done. For an ordinary family, in a house of 10 rooms

or less, a grease trap 6 inches in diameter by 10 inches deep is commonly used. For houses larger and a grade better, a grease trap 10 inches by 14 inches is very often used. Probably the most simple method for determining the sizes of ordinary grease traps, for hotels and apartment houses, is as follows: Divide the number of people by 5 to 10 and the quotient will be the capacity of the grease trap in gallons. Of course, a great deal depends upon the make of the trap; some are better intercepters than others, because they throw the grease to the surface where it solidifies; others, again, are so constructed that the hot-water-and-grease mixture passes almost directly through the body of the water in the trap, and has neither time nor chance to leave the grease behind. (*b*) Simply unscrew the cap or bonnet, and scoop out the grease and other solids. Then screw the cap on again, being sure to make it gas-tight. (*c* and *d*) Yes. All spring gauges should be condemned for this work, because they are so liable to stick. It requires considerable variation in pressure to move the parts of an ordinary spring gauge. We recommend the mercury gauge. The outfit costs about $12.00. (*c*) Yes, but it is not easy to do so. If you suspect trickery in a test, just unscrew a cap at the far-away end of the system, and let down the pressure. If the gauge still shows pressure, then the nipple is plugged up or some other simple trick is being played.

***

(31) (*a*) Is there a standard length of thread for steam pipes? If so, please give the lengths for all commercial sizes up to 12-inch pipe. (*b*) In the enclosed sketch, *p* is a piston 3 inches in diameter, fitted with the valve *v* 1 inch in diameter. If the steam pressure on the upper side of piston is 80 pounds per square inch, what pressure of steam will it take under the valve to lift the piston? Kindly show figuring. E. W. R., Belleville, N. J.



ANS.—(*a*) According to Brigg's "Standard of Wrought-Iron Pipe Dimensions," the length of perfect screw thread is determined by the formula

$$L = \frac{.8\,D + 4.8}{n},$$

where D = actual outside diameter;

n = number of threads per inch;

which gives for the various nominal sizes the following values:

⅛	¼	⅜	½	¾	1	1¼	1½	2	2½	3
.19	.29	.30	.39	.40	.51	.54	.55	.58	.89	.95

3½	4	4½	5	6	7	8
1.00	1.05	1.10	1.16	1.26	1.36	1.46

9	10	11	12
1.57	1.68	1.80	1.92

(*b*) The total pressure on the valve must be equal to the total pressure on the piston.

Total pressure on valve =

$$\text{area of piston} \times 80 = \frac{\pi}{4} \times 3 \times 3 \times 80.$$

Total pressure on piston =

$$\text{area of valve} \times x = \frac{\pi}{4} \times 1 \times 1 \times x,$$

in which x = pressure per square inch on valve, to be found.

Equating these two pressures, we have

$$9 \times \frac{\pi}{4} \times 80 = \frac{\pi}{4} \times x;$$

or $$x = 9 \times 80 = 720 \text{ pounds}.$$

(32) Is there a book published which, if thoroughly mastered, will enable a railroad pile inspector to distinguish white oak from any other timber under any and all circumstances? If there is, give me the name, price, and where it is on sale.

J. B. G., Fort Smith, Ark.

ANS.—The only book that we know of giving specific and reliable information on this subject is "The Materials of Construction," by Prof. J. B. Johnson, price $6.00; for sale by The Technical Supply Company, Scranton, Pa. The portion of this book relating to timber, however, is taken chiefly from Bulletin 10, of the U. S. Forestry Division, Department of Agriculture, 1895; B. E. Fernon, Chief of the Division.

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(33) (*a*) Kindly inform me how I can make a perfectly pure soap containing a large percentage of glycerine, for toilet use. I wish to do this at home. I am somewhat enthusiastic on the subject of soap, but confess that I do not know what constitutes a *pure* soap. I need a very cleansing article, as my hands get very grimy at my work. (*b*) How can I make a safe and durable electric heater for (1) a 500-volt circuit and (2) a 100-volt circuit?

MINER, Forest Hill Divide, Cal.

ANS.—(*a*) Glycerine soap may be prepared by melting Castile soap and mixing with it about $\frac{1}{10}$ part of its weight of pure glycerine; or, it may consist of the following:

Tallow (mutton)	44 lb.
Cocoanut oil	44 lb.
Castor oil	22 lb.
Glycerine	22 lb.
Caustic lye	27 lb.
Alcohol (96°)	48.4 lb.
Water	9.9 lb.

Melt the grease, and add the caustic lye slowly, keeping the temperature low, say about 100° F., to prevent evaporation, and stir constantly. When the lye has become absorbed, after about 3 or 4 hours' stirring, add the alcohol; stir until it becomes clear, then add the glycerine, and, when mixed, the water. This latter recipe is highly recommended; we have, however, never tried it personally, and would advise you to try it first with small quantities, or use the first recipe. (*b*) Make an iron frame and wind on it 750 feet of No. 16 B. & S. gauged galvanized-iron wire. Insulate the wire from the frame with asbestos. This heater is designed for use on a 100-volt circuit. For a 500-volt circuit, connect five such heaters in series, or wind one with five times the amount of wire of the same size.

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(34) (*a*) What is the lowest pressure that will cause gasoline to explode in a gasoline engine? (*b*) Is it possible to pump sufficient gas into the cylinder of a gasoline engine (the engine being on dead center) to insure starting with single explosion—the engine first being turned over to favorable position? (*c*) Why is it impossible to make a double-stroke gasoline engine when using but one cylinder?

J. R., Kanopolis, Kan.

ANS.—(*a*) Pressure alone will not ignite gasoline. Compression of a mixture of gasoline *vapor* and air will, if carried far enough, produce a temperature sufficiently high to fire the mixture. The pressure required in such a case is in the neighborhood of 500 pounds per square inch. (*b*) Yes, if properly managed, and the engine is started without a load. (*c*) We understand you to mean an engine giving two explosions to each revolution. Such an engine is undoubtedly possible, but there are many mechanical difficulties in the way, which a study of the gas engine will soon make clear to you.

SELF HELP DEPARTMENT.

WHERE THERE'S A WILL THERE'S A WAY.

"WHERE there's a will there's a way," is just as true of educational as of any other pursuits. Sir Joshua Reynolds was so earnest a believer in the force of industry that he held that all men might achieve excellence if they would but exercise the power of assiduous and patient working. He held that drudgery lay on the road to genius, and that there was no limit to the proficiency of an artist except the limit of his own painstaking. He would not believe in what is called inspiration, but only in study and labor. "Excellence," he said, "is never granted to man but as the reward of labor. If you have great talents, industry will improve them; if you have but moderate abilities, industry will supply their deficiency. Nothing is denied to well-directed labor; nothing is to be obtained without it." Sir Fowell Buxton was an equal believer in the power of study; and he entertained the modest idea that he could do as well as other men if he devoted to the pursuit double the time and labor that they did. He placed his great confidence in ordinary means and extraordinary application.

"I have known several men in my life," says Dr. Ross, "who may be recognized in the days to come as men of genius, and they were all plodders, hard-working, *intent* men. Genius is known by its works; genius without works is a blind faith, a dumb oracle. But meritorious works are the result of time and labor, and cannot be accomplished by intention or by a wish. Every great work is the result of vast preparatory training. Facility comes by labor. Nothing seems easy, not even walking, that was not difficult at first. The orator whose eye flashes instantaneous fire, and whose lips pour out a flood of noble thoughts, startling by their unexpectedness and elevating by their wisdom and truth, has learned his secret by patient repetition, and after many bitter disappointments."

Thoroughness and accuracy are two principal points to be aimed at in study. Francis Horner, in laying down rules for the cultivation of his mind, placed great stress upon the habit of continuous application to one subject for the sake of mastering it thoroughly; he confined himself with this object to only a few books, and resisted with the greatest firmness "every approach to a habit of desultory reading." The value of knowledge to any man consists not in its quantity, but mainly in the good uses to which he can apply it. Hence, a little knowledge of an exact and perfect character, is always found more valuable for practical purposes than any extent of superficial learning.

By spreading our efforts over too large a surface, we inevitably weaken our force, hinder our progress, and acquire a habit of fitfulness and ineffective work. Lord St. Leonards once communicated to Sir Fowell Buxton the mode in which he had conducted his studies, and thus explained the secret of his success: "I resolved," said he, "when beginning to read law, to make everything I acquired perfectly my own, and never to go to a second thing till I had entirely accomplished the first. Many of my competitors read as much in a day as I read in a week; but at the end of twelve months, my knowledge was as fresh as the day it was acquired."

This unconquerable determination to master whatever subject is taken in hand, is illustrated by numberless examples in American history. The lives of Lincoln, Greeley, and Garfield, all nobly emphasize its successful application.

What unconquerable determination has done for thousands of American boys it has likewise achieved for the courageous foreign-born citizen.

"Peanuts, ten cents a quart! Bananas, fifteen cents a dozen!" cried a rough-clothed foreigner in the streets of Kansas City, ten years ago; but that foreigner had mastered Legendre's Geometry in French, could quote Homer by the thousand lines, and knew the classics of his native Russia.

When Russia chooses to make exiles of her best minds, ours is sometimes the gain. Leo Wiener, a precocious boy, was sent to Berlin to study. He tasted freedom, and carried the air of liberty back to Russia. He spoke for freedom, and was banished. He escaped from Siberia, tramped through Germany, France, and Spain, and took passage to Cuba. During the two weeks of the voyage, by studying twelve hours a day, he mastered the Spanish language. Cuba could not hold him. At New Orleans, he studied the hardest language he had ever met, the English. "Even now, with twenty-seven languages at command, he halts and stumbles oftenest in speaking English."

"Wiener drifted to Kansas City," says the New York "Herald," "and was without a penny when he reached there. To become a peddler was his purpose; bananas and peanuts his stock in trade. For months, his expenses were fifteen cents a day; but he was learning English all the time. The public library on the hill, night after night, received him; he called for the best English literature. J. M. Greenwood, Superintendent of Schools, became interested in him; he was curious to know who that shabby man was who pored over the classics. Soon he found a pretext for forming his acquaintance, and it did not take him long to discover that this quiet student was a man of fine scholarly attainments. Through his influence, Wiener secured a good position as teacher. As his qualifications became better known, his advancement followed, and honor, reputation, and an assured income accompanied the recognition. The poor exile who formerly peddled peanuts on the public streets is now a distinguished professor in a western university.

POWER OF HABIT.

EPICTETUS, a Stoic philosopher of the first century of the Christian era, speaking of habit, made use of the following language: "Every skill and faculty is maintained and increased by the corresponding acts; as, the faculty of walking by walking, of running by running. Thus, if you have lain down for ten days, and then rise up and endeavor to walk a good distance, you shall see how your legs are enfeebled. In general, if you would make yourself skilful in anything, then do it; and if you would refrain from anything, then do it not." This sounds very much like the doctrine of learning to do by doing, which is therefore a very ancient philosophy.

"THAT BOY'LL NEVER GET ALONG."

HORACE GREELEY'S farm life terminated with his fifteenth year. As a farmer he was a decided failure. "That boy'll never get along in the world," said Zaccheus Greeley, when his son in a fit of abstraction tried to yoke the "off" ox to the "near" side. "He'll never know more than enough to come in when it rains."

When five years old, Horace had declared his intention of becoming a printer—a purpose which for ten labor-filled, discouraging years he steadily held. It was thus that he happened to stand in that East Poultney garden, having walked eleven miles, asking to be made a printer's apprentice. In the office the boys teased him with saucy remarks, threw type at him, and finally blackballed his white hair. But he never paused to retaliate. Dodging the type and washing his hair, he quietly resumed his work. Finding that he could not be irritated or hindered, his companions adopted him as a prime favorite.

He soon began to set up original paragraphs without writing them. He joined a debating society composed of the doctor, the lawyer, the school teachers, and other intelligent people of East Poultney, and soon became the leader in debate. He never lost his temper, always argued fairly, never hesitated, and found no difficulty in answering the most abstruse argument or question. He came to be considered an authority on mooted questions, and was always listened to with deference, in spite of his entire lack of conventional manners, his clodhopper appearance, his ungainly attitude, and grotesque garb.

The last issue of the "Northern Spectator" was sent out at eleven o'clock one June morning in 1830; and in the afternoon, at one o'clock, Horace Greeley, with a stick and small bundle resting on his shoulder, and an overcoat on his arm, which Mr. Hosford, with whom he had boarded, had given him (the first he ever had, and which probably lasted until he obtained his white one), bade adieu to friends in Poultney, and started on foot for his father's home in Pennsylvania, five hundred miles away.

After several weeks at home, he sought work in various directions. He finally anchored at Erie, Pa., a large and busy town with two printing offices. He found employment with the "Erie Gazette," though its editor long demurred at accepting so "green" a hand at fifteen dollars a month. Out of his seven

months' earnings at Erie he sent twenty-five dollars to his father, reserving six dollars for himself. Convinced that if he was to succeed in any considerable sense, he must do so in a large place, he decided to try his fortune in what he calls the "Commercial Emporium."

On August 18, 1831, at six o'clock in the morning, Horace Greeley entered New York, "an overgrown, awkward, white-headed, forlorn-looking boy; his pack suspended on a staff over his right shoulder; his dress unrivaled in sylvan simplicity since the discovery of America; the expression of his face presenting a strange union of wonder and apathy. Ignorant alike of the world and its ways, he seemed to the denizen of the city almost like a wanderer from another planet."

Having secured, after long inquiry, board at two dollars and a half a month, he set out to find employment. After hundreds of refusals and numerous disheartening experiences, he was offered a job which no one else would accept. This was to set up a Testament, "the text thickly studded with references by Greek and superior letters, to the notes, preceded and discriminated by corresponding indexes, with prefatory and supplementary remarks on each book." The subsequent history of Horace Greeley has been told and retold, his engagement with the "Spirit of the Times," his dismissal from the "Commercial Advertiser" for "having decent-looking men in the office," his connection with the "Bank Note Reporter," his establishment of the "New Yorker," superior in those days to any literary publication which had preceded it, and his connection with the "Jeffersonian," and finally his editorship of the great paper which made his name and his fortune.

ORDER AND REGULARITY.

DISCUSSING the essentials of education, President Andrews pays due tribute to order and regularity when he says:

"The information given should be orderly and regular. It is important that one should know facts, but more important that they should be known orderly and in their proper connections. And this is the great advantage of the schools. Few facts or none are taught at any school which might not be had by reading. But there is a difference between the discipline of the schools and intellectual browsing. In this lack of order and proportion of knowledge lies the weakness of most self-made men. A great many men prominent in the economic and intellectual world have been self-made men. Their minds have been of the first class. But they have lacked this orderliness of school education, and all their work has shown it. When I find young people talking about picking up an education, from newspapers, magazines, libraries, and lectures, and the sermons of great preachers, I always beg them not to delude themselves into the idea that they can become, in any proper sense, truly educated, unless they can go to school for a little while at least.

"First of all, then, gain character, then culture, then information, with accuracy. But let this information be ordered information, such as the school gives, and not merely general information, jumbled information, information shoveled together in great heaps, as men shovel together corn or wheat."

In the regular gradation and logical consecutiveness of their courses of study and of the subjects taught in each course, The International Correspondence Schools are unsurpassed by any and equaled by few existing educational institutions.

THE CALL TO STUDY.

"O Human Soul, study thyself! Study thine own powers, improve and deify thy manhood! For thou alone of all creatures wert made in divine image and likeness."

"On a skull," said Mr. J. P. McCaskey, in one of the most beautiful addresses we have ever read, "these words were written: 'Lamp, what hast thou done with the flame? Skeleton, what hast thou done with the soul? Deserted cage, what hast thou done with the bird? Volcano, what hast thou done with the lava? Slave, what hast thou done with thy master? Death, what hast thou done with life.'"

Words of startling and striking significance, that should enter deeply into every human heart, touched by their sound, moved by their reading! What is man but for his soul? What is the soul of man unimproved by reflection, study, and self-culture?

Without a soul man were among the most infirm and helpless of creatures! Without a mind improved and cultivated, he is unworthy of his high rank as the first of God's creatures.

Shakespeare makes Hamlet say: "What a piece of work is man! How noble in reason! How infinite in faculties! In form and moving, how express and admirable! In action, how like an angel! In apprehension, how

like a god! The beauty of the world! The paragon of animals!"

Chapin says: "Man was sent into the world to be a growing and exhaustless force. The world was spread out around him to be seized and conquered. Realms of infinite truth burst open above him, inviting him to tread those shining coasts along which Newton dropped his plummet, and Herschel sailed, a Columbus of the skies!"

Carlyle: "We are the miracle of miracles—the great inscrutable mystery of God. We cannot understand it, we know not how to speak of it; but we may feel and know, if we like, that it is verily so."

And Theodore Parker: "The discoverer finds nothing so grand or tall as himself, nothing so valuable to him. The greatest star is that at the little end of the telescope—the star that is looking, not looked after nor looked at." And again: "Man is the jewel of God, who has created this material world to keep his treasure in."

Emerson: "O rich and various man, thou palace of sight and sound, carrying in thy senses the morning and the night and the unfathomable galaxy; in thy brain the geometry of the city of God; in thy heart the power of love and the realms of right and wrong! An individual man is a fruit which it cost all the foregoing ages to form and ripen. He is strong not to do, but to live; not in arms, but in his heart; not as an agent, but as a fact."

"Man perfected by society," says Aristotle, "is the best of all animals! He is the most terrible of all when he lives without law and without justice."

"Omit a few of the most abstruse sciences," says another observant thinker, "and mankind's study of man occupies nearly the whole field of literature. The burden of history is what man has been; of law, what he does; of physiology and the story of today, what he is; of ethics, what he ought to be; of revelation, what he shall be."

In the Book of Genesis we have this, when written and by whom no man can tell: "And God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth. So God created man in his own image; in the image of God created he him; male and female created he them. * * * And God saw everything that he had made, and behold it was very good."

And Paul, writing to the Corinthians, says to them: "Know ye not that ye are the temple of God, and that the Spirit of God dwelleth in you? If any man defile the temple of God, him shall God destroy; for the temple of God is holy, which temple ye are." Again: "What! know ye not that your body is the temple of the Holy Ghost which is in you, which ye have of God, and ye are not your own?"

It is only by the cultivation of the godlike in man that he can rise superior to fear, to selfish interest and corruption, to become a man with a mind governed by principles of uniform rectitude and integrity, the same in prosperity as in adversity, whom no bribe can seduce, or terror overawe, whom pleasure cannot melt into effeminacy, nor distress sink into dejection—in a word, a man with the true distinction and eminence of manhood. The godlike in man cannot be cultivated without study, which, by giving man knowledge of himself and his relations as well to God as to his fellows and to the external world in which he is placed, gives firmness and constancy; makes him true to the Maker whom he worships; full of affection for mankind, faithful to friends, generous to enemies; warm with compassion for the unfortunate; self-denying to petty interests and pleasures, but zealous for the common weal and interest; magnanimous without pride; humble without meanness; just without severity; simple in manners, but manly in feeling; a man whose word is as good as his bond; whose professions never deceive us; one whom we would cheerfully follow as a leader, trust as a friend, love as a brother.

STEADFASTNESS AND SUCCESS.

IT CANNOT be too often repeated that it is not men of genius who move the world and take the lead in it so much as men of steadfastness, purpose, and indefatigable industry. Notwithstanding the many undeniable instances of the precocity of men of genius, it is nevertheless true that early cleverness gives no indication of the height to which the grown man will reach. Precocity is sometimes a symptom of disease rather than of intellectual vigor. What becomes of all the "remarkably clever children"? Where are the prize boys? Trace them through life, and it will frequently be found that the dull boys, who were beaten at school, have shot ahead of them. The clever boys are rewarded, but the prizes which they gain by their greater quickness

and facility do not always prove of use to them. What ought rather to be rewarded is the endeavor, the struggle, and the obedience; for it is the man who does his best, though endowed with an inferiority of natural powers, that ought above all others to be encouraged.

NATURE A TEACHER.

IN HIS book, "Nature's Teachings," the Rev. J. G. Wood discusses a subject not before handled at length. Its object is to show how man's implements and mechanical devices have been anticipated in use in nature for countless centuries. He claims that the great discoverers of the future will be those who carefully study the natural world.

The burr stones of mills are, for instance, a copy of molar teeth. The hoofs of a horse are made of parallel plates like a carriage spring. The finest file made by man is a rough affair when compared with a Dutch rush used by cabinetmakers. The jaws of the turtle and tortoise are natural scissors. Rodents have chisel teeth, and hippopotami have adz teeth, which are constantly repaired as they are worn. The carpenter's plane is anticipated by the jaws of the bee. The woodpecker has a powerful little hammer. The diving bell only imitates the work of the water spider. This insect, although as easily drowned as any other, spends a great part of his life under water. Having constructed a small cell under the water, it clasps a bubble of air between its last pair of legs, and dives down to the entrance of its cell, into which the bubble is put. A proportionate amount of water is thus displaced, and when all of it is expelled, the little animal takes up its abode in this subaqueous retreat.

In laying its eggs on the water, the gnat combines them in a mass shaped somewhat like a life boat. It is impossible to sink it without tearing it to pieces. The iron mast of a modern ship is strengthened by deep ribs running along its interior. The porcupine quill is strengthened by similar ribs. When engineers found that hollow beams were stronger than solid ones of the same weight they only discovered a principle used in nature long before the creation of man. A fragile wheat straw can support a heavy head. The bones of the higher animals, if solid, would have to be a great deal heavier to bear the weight which they have to support. The framework of a ship resembles the skeleton of a herring, and those who would improve aerial navigation are studying the skeleton of a bird with advantage. Palissy made a careful study of the shells by the seaside in order to learn the best method of fortifying a town.

The ship worm feeds on wood, and gradually tunnels its way through any submerged timber. It also lines its burrow with a hard, shelly coating. Brunel, taking a hint from this, was the first to succeed in subaquatic tunneling. The Eddystone Lighthouse is built on the plan of a tree trunk, and fastened to the rock in a manner somewhat similar to the way a tree is fastened to the soil. It is supposed that the first idea of a suspension bridge was suggested by the creepers of a tropical forest.

Mr. Wood gives an interesting account of the origin of the plan of the Crystal Palace. Mr. Paxton, a gardener, having noticed the structure of the great leaves of the Victoria Regia, a plant which had been introduced into England a few years previous, struck the plan of copying in iron the ribs of the leaf and filling the remaining space, which corresponds to the cellular portions of the leaf, with glass. Thus, by copying nature, an obscure gardener became Sir Joseph Paxton, the great architect.

EDUCATION'S TRUE AIM.

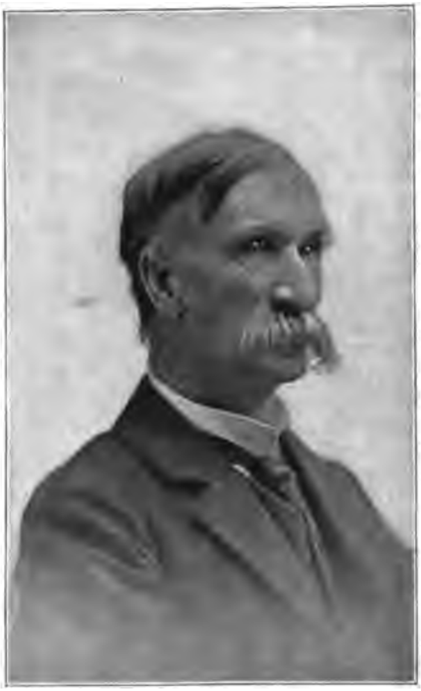
ON THIS subject W. F. Gordy bears telling testimony: "The education of a child should not be considered as simply fitting him for making his way in the world, but should aim to develop high ideals and a character full of nobility and force. Preaching and moralizing will not do this, but the parent and teacher must have individuality and character of the right kind to illustrate and enforce the ideals which they wish children to receive. We cannot describe the effect which a beautiful landscape, a wonderful piece of art, or a favorite essay has upon us, but the effect is none the less real and helpful, and the teacher who can suggest the good and beautiful in a way to develop the sensitiveness of his scholars, is the true educator. Mathematics and the exact sciences are not to be underestimated as a part of school training, but history and literature are most important, because through the lives of great men and the individuality of authors this sensitiveness to high ideals is cultivated. Lincoln is one of the greatest teachers in American history, second only to Washington himself."

A SELF-MADE MAN.

From Miner to Financier and Congressman.

AMONG the many notable examples of successful men who, through their own efforts, have risen from obscurity to positions of distinction, it would be difficult to select one more brilliant in its development, or more inspiring in its effect upon the thousands of men who are striving to attain success amid difficulties and discouragements, than that of the Hon. William Connell.

He was born on the 10th of September, 1827, at Cape Breton, Nova Scotia, of Scotch-Irish parentage, his father being a laborer in the Cape Breton mines. He had few educational advantages, as, early in life, it became necessary for him to assist in the support of the family. Yet, by studious application, he acquired a sufficient knowledge of the rudimentary English branches to form a solid foundation upon which to build in later years. He was a careful student of the Bible, memorizing large portions of it, and was also fond of Shakespeare and Milton. The study of these works early awakened in him such a desire for knowledge and self-improvement that he was ever on the alert for anything which would add to his meager education. To observation and "always doing his best" he attributes his remarkable success.



In 1844, the family removed from Nova Scotia to Luzerne County, Pennsylvania, where both father and son secured employment in the newly opened anthracite coal fields of the Lehigh region. The twelve years of hard labor that followed covered a period of great self-improvement. He effectively mastered the intricate science of mining, and, by study, acquired the necessary technical knowledge to qualify himself as an expert. In 1855 his intelligence and industry secured him a position as superintendent of a colliery owned by The Susquehanna and Wyoming Valley Railroad and Coal Company.

Mr. Connell had always made it a rule to save part of his salary, however small. This frugality enabled him, five years after his arrival in Scranton, to join with seven others in buying a colliery. At the opening of the Civil War, the price of coal rose, and the colliery was sold to a syndicate, Mr. Connell realizing a large sum from the transaction.

In 1870 the charter of The Susquehanna and Wyoming Company expired, and Mr. Connell purchased the property and organized the firm of Wm. Connell & Company. He soon became the most notable figure in the financial, manufacturing, and mining circles of Northeastern Pennsylvania, and has twice been elected to Congress.

Remembering the difficulties which had attended his own efforts to secure an education, he has always been interested in educational enterprises and institutions, and is a trustee of several universities.

The history of William Connell is a forcible illustration of what an indomitable will, a clear mind, well directed energy, and sterling integrity will accomplish. From boyhood up he made the most of every opportunity to increase his stock of knowledge, by observation and by study.

STUDENTS WHO HAVE BENEFITED THEMSELVES

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PASSES ARCHITECTURAL EXAMINATIONS.

For a little over two years I have been studying the Complete Architectural Course of The International Correspondence Schools, and have found it of great value. Recently I took the examinations for a license to practise architecture, as required by this state, and passed at the head of the class. I was greatly assisted in so doing by the information obtained in the Instruction Papers.—*Ira A. Worsfold (A. 500), 149 Park Ave., Waukegan, Ill.*

SECURED LICENSE AND MORE SALARY.

I can recommend The International Correspondence Schools to any one. Since I have been studying in the School of Steam Engineering, I have obtained papers as first assistant engineer on steamers of any tonnage, and as chief engineer on steamers of 100 gross tonnage. I would have been unable to obtain my marine license if I had not taken the course. I now have a position as chief engineer, my wages have been increased to $75.00 per month, and there are better prospects ahead. I will be pleased to answer all letters regarding the Schools. *C. H. Golloher (H. 441), Morgan City, La.*

FIRST-CLASS ENGINEER'S LICENSE AND MORE SALARY.

I am afraid my humble pen is inadequate to express the great benefits derived from my course of study in the Schools. A first-class engineer's license, a better position with a large increase in salary, a greater confidence in my own ability, are a very few of the benefits. Too much praise cannot be given to The International Correspondence Schools for the painstaking, thorough manner in which they teach the pupil. No one need go through life uneducated while there is such an institution in existence.—*Frank E. Demar (H. 2015), 131 West St., Hyde Park, Mass.*

SUPERINTENDENT OF AN ELECTRIC-LIGHT PLANT.

It gives me great pleasure to speak of the merits of The International Correspondence Schools. My course in Electric Power and Lighting has benefited me in several ways. It has fitted me for the position which I now hold as superintendent of The Lansdale Electric-Light Works. I would not have been capable of holding this position had it not been for the course I took at the Schools.—*J. M. Fine (J. 806), Lansdale, Pa.*

SERVICES ARE IN DEMAND.

I longed to obtain more knowledge of stationary engineering, but was unable to go through college. When I enrolled in The International Correspondence Schools, I was working for $1.50 per day. I now have a position as licensed engineer at $3.00 per day. Since I obtained my diploma, several good places have been offered to me, and I never shall regret taking the step which has changed my whole life.—*D. A. Strong* (*H. 126*), *2320 Michigan Ave.*, *Chicago, Ill.*

BECAME A MINE SUPERINTENDENT.

I have worked in and about the mines since I was ten years of age, and until five years ago was almost where I started. I determined to take a course in The International Correspondence Schools, and since then I have been able to pass both fire-boss and mine-foreman's examinations. For the past three years I have been superintendent for The Ohio and Pennsylvania Coal and Coke Co., at Port Royal, Pa. I cannot recommend the schools too highly as an opportunity for men who have been deprived of an education, to learn the most approved methods of the day. Every ambitious miner should certainly take the course.—*Michael A. Roy* (*C. M. 1191*), *Fitz Henry, Pa.*

MADE HIMSELF A DRAFTSMAN.

With no previous knowledge of mechanical drawing, or the theory of any trade, I enrolled in The International Correspondence Schools. I now hold a position of responsibility as draftsman on a varied line of machinery. The closeness with which my school work was corrected has made my shop work above the average in neatness and accuracy. The knowledge obtained through the instruction has enabled me to intelligently apply the principles of mechanics in my work. My advice to any young man is to get an education in the theory of his trade. It will enable him in one year to acquire knowledge which could otherwise be gained only by several years' experience.—*J. S. Myers* (*M. E. 1362*), *Chambersburg, Pa.*

A SANITARY PLUMBER.

I have found the instruction of The International Correspondence Schools much more practical than I had anticipated, and am pleased to recommend it as thorough and efficient. I have recently had the opportunity to fit up the plumbing and drainage of a house, which was the first I was to oversee alone. Everything was carried out as I was taught by the Schools, and all worked well and was satisfactory to the owner.—*Asa F. Houck* (*P. 19*), *Bloomsbury, N. J.*

"Count that day lost, whose low descending sun
Views from thy hand no worthy action done."—*Anon.*

* * * * * * * * * * * * *

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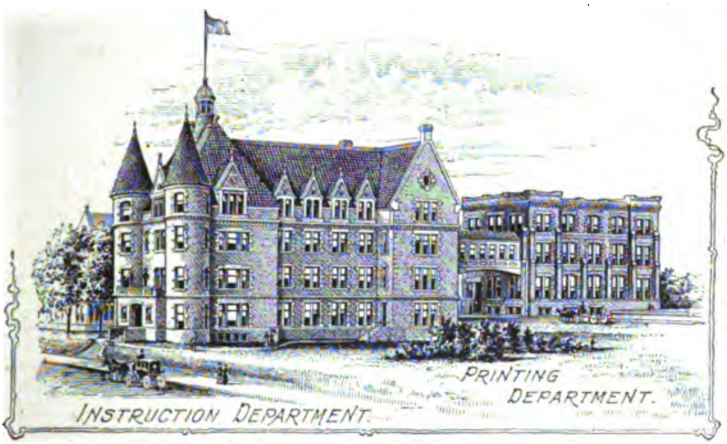

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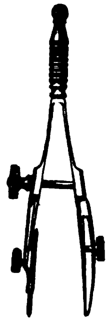

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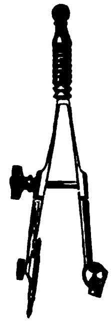

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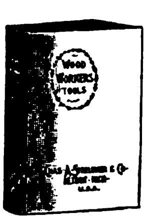

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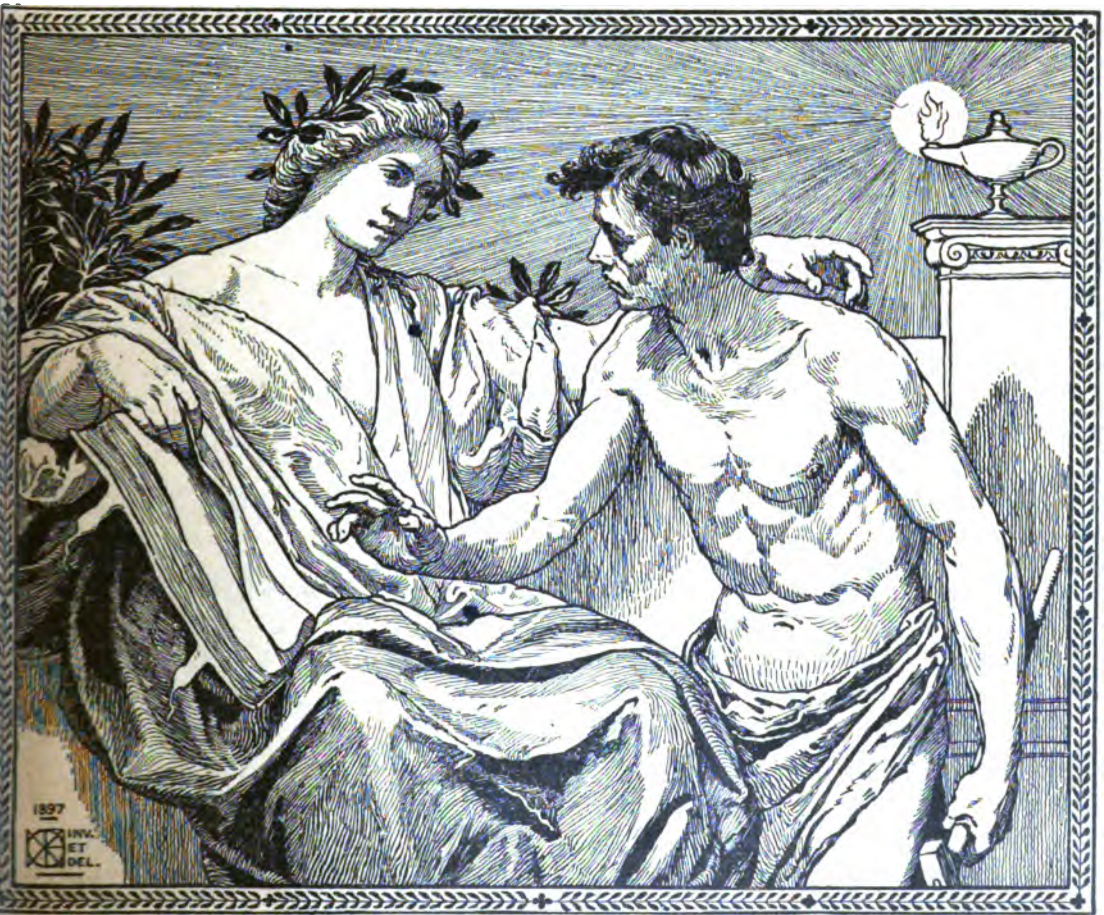

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RAILROAD BLOCK SIGNALING.

George F. Lord.

THE SEVERAL SYSTEMS NOW IN USE—CONTROLLED MANUAL SYSTEM AS ADOPTED BY THE NEW YORK CENTRAL, AND THE IMPOSSIBILITY OF COLLISION IF SIGNALS ARE OBEYED.

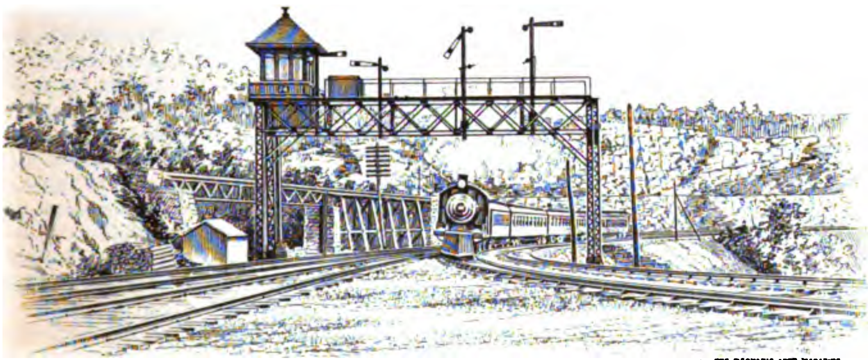

FIG. 1.—THE EMPIRE STATE EXPRESS, AT LITTLE FALLS.

THE primary purpose of all railroad signaling is the same, namely, the protection of trains from collision. But the means by which this purpose may be accomplished are widely different, depending largely on the amount of traffic, and the speed of the trains. The earliest method of signaling was by flagmen, stationed at intervals along the track, each man, with flag by day and lamp by night, protecting the train just passed until it reached the next man.

Another system, extensively used at one time, and still employed, is what is known as the "time block system," in which, after a train has passed a given signal station, a certain length of time is required to elapse before the next train is allowed to pass the same station. But this system is quite unreliable, as it gives no information as to what *distance ahead* the previous train may be; and it is this distance ahead, or *space interval*, not the *time interval*, that is of greatest importance. This is obvious; for, if a train is a certain safe distance ahead of another, collision is impossible, whether the time interval is one minute or one hour.

Under the various "block systems," the railroad is divided into blocks, having at each end signals that control the track in the block ahead (viewed from the engine), and render it impossible for two trains to be in the same block, on the same track, at the same time, unless the engineer disobeys the signal or the signalman displays a wrong signal. Three distinct systems of block signaling are recognized: telegraphic, automatic, and controlled manual.

In the *telegraphic* system, the signalmen—who are usually the station agents—throw their signals to "clear" or "danger" on receipt of telegraphic information. But there is nothing to prevent the signalmen from giving a wrong signal (either through carelessness or design), and causing a collision.

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Automatic signals are operated by the passage of the train itself, the motive power being either electricity or compressed air. But, since there is nothing to indicate to the engineer whether the signal is at danger because it ought to be, or because the apparatus has failed to work, it is necessary to allow him to proceed with caution after the lapse of a stated interval of time.

The system now in operation on the New York Central is the *controlled manual*, in connection with "track circuits." The signals are thrown by hand levers, but they are electrically locked in such a manner that it is impossible to give a "clear" signal in error.

In order to understand the operation of

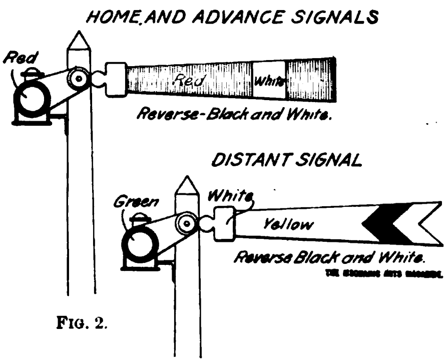


FIG. 2.

FIG. 3.

this system, it is necessary to become acquainted with the various details of which it is composed. First in importance are the signals. These are variously known as the "home," "advance," and "distant" signals. Fig. 2 is an illustration of the home and the advance signals, which are alike in appearance. On these signals the semaphore, or painted blade, extends to the right of the post—as viewed from the approaching train—and is painted red with a band of white near the outer end, the reverse side being white with a black band. On the other end of the blade is a circular frame holding a sheet of red glass, behind which, at night, the light is placed. The blade horizontal indicates, "Danger! Stop." The blade dropped into a position approaching the vertical means, "Clear! Go ahead." These are the day signals. At night the red light means, "Danger!" the white light, "Go ahead."

The distant signal is illustrated in Fig. 3. The blade of this signal is yellow with a forked end, and a black band near the end. The glass in front of the lamp is green. The distant signals are placed 1,800 feet or more from the home signals at all interlocking towers, and at block towers when the view of the home signal is obscured. It indicates the position of the home signal; and the blade in a horizontal position by day, or a green light by night, means, "Caution! Proceed to the home signal with train under full control." The blade in a nearly vertical position by day, or a white light by night, means that the home and the advance signals are clear.

At interlocking towers it sometimes becomes necessary to allow a train to stand near the home signal while switching movements are made in the block ahead or in the rear. For this purpose a short block is provided in which the train may stand. The end of this block is marked by the advance signal, which controls the block ahead, while the home signal merely marks the end of the block in the rear and protects the train in the short block. The distant signal is interlocked with the home and the advance, so that it is impossible to clear the distant unless the home and the advance are clear.

Where there are "facing-point" switches on main tracks (by a *facing-point* switch is meant one in which the point of the switch faces the train when moving in the direction of traffic), it is necessary to provide one signal for the high-speed route and one for the diverging route. For this purpose two blades are placed on the same post, the upper indicating for the high-speed route, the lower for the diverging route.

Home signals are located on bridges spanning the track, or on posts standing near the tracks which they govern. Fig. 1 shows the Empire State Express passing under Tower 24, Little Falls, Mohawk Division. The New York Central has four tracks. The two to the right of the view are the passenger tracks, and the two to the left, the freight tracks. The two middle tracks are for west-bound trains, while the two outside tracks are for those bound east. The signals for passenger tracks are always placed higher than those for freight tracks, as in the illustration. It is impossible for the engineer to mistake his signal, as only two red signals are visible (the other two showing white and black), and one of these is higher than the other. These signals are normally at danger (clearing only to allow the passage of a train), and will go to danger in case of breakage of the apparatus. In Fig. 1 all signals are at danger except the west-bound passenger signal, which is cleared for the passage of the train.

Next in importance to the signals are the machines, or systems of levers, by which the signals are moved. In Fig. 4 is shown the interior of a tower, with the operator standing at the machine. The ordinary machine consists of but four levers, while this has double that number. The extra levers are connected to distant signals, and signals protecting a cross-over from another road. These levers are provided with latches, as shown at *a*. It is the locking and unlocking of these latches by electrical devices that maintains the efficiency of the system.

Fig. 4.

On the shelf over the machine is a cabinet containing a set of four block instruments and electric locks, one for each track, as shown in detail in Fig. 5. Behind the glass fronts of the cabinet are mats of blue paper, with open spaces in the middle. In these spaces are cards which read, "Locked," "Train in Block," and "Free." Above the space containing the cards, there is also a miniature semaphore for each track, as shown, the function of which will be explained later. The electric locks are placed on the back of the machine, one for each lever.

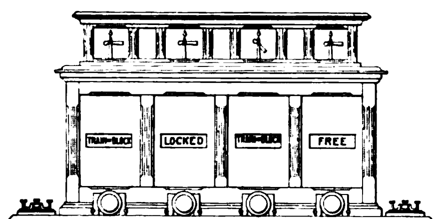


Fig. 5.

On each side of the table of the machine is a key for making or breaking the bell circuits. There is an electric bell on each side of the tower (east and west), one being smaller than the other, so that the tones are distinguishable from each other. All the towers are connected electrically by a cable of wires, and are in telegraphic communication. The signal system itself, however, is operated almost entirely by a code of bell signals, each tower communicating with the tower immediately in the rear and with the one preceding.

Perhaps the crowning feature of the system is the combination of the track circuits with the manual machine, as it is this element which makes it impossible for the signalman to give a clear signal in error. An idea of its operation may be gained by referring to Fig. 7. At the end of each block, a section of track, three rails in length, is insulated by pieces of pressed paper (amounting to ½ inch in thickness), placed between the ends of adjoining rails. As the insulation would be spoiled by the ordinary fish-plates, these are replaced by two heavy pieces of oak, called "splice-woods," which are bolted together on either side of the rails, thus holding the two ends firmly in position. Each of these "electric blocks" is provided with a battery *B*, and is connected electrically with the locks on the machines. Suppose that the normal course of the current was from *B* at *2* to the lower rail, and thence through the magnet *D*—in the tower—returning through *1* to *B*. The condition at *L* would be that the circuit *A E X* would be made by the attraction of the armature *A* by *D*. When, however, the forward wheels of the train enter upon this section of track, the current is short-circuited by the wheels and axle. The circuit *A E X* is then broken, as shown at *M*, by the release of the armature *A*.

Before explaining the operation of the system, it is necessary to acquaint the reader with the principal bell signals now in use in the towers:

One bell: "Yes. All right."

Two bells: "Train has cleared—passenger track."

Two bells and one: "Train has cleared—freight track."

Three bells: "Unlock my lever—passenger track."

Three bells and one: "Unlock my lever—freight track."

Four bells: "Train has entered block—passenger track."

Four bells and one: "Train has entered block—freight track."

It will be noticed that all signals for freight tracks are the same as for passenger tracks, except that they are followed by one bell. Various other signals are provided, but these are the ones in ordinary use.

We will now endeavor, with the aid of Figs. 5 and 6, to explain the working of the system. *X-L*, Fig. 6, represents a section of passenger track; *A*, *B*, *C*, and *D* are signal towers. The large semaphores represent the track signals. The fronts of the instruments for this particular track are shown below, while the short space under each tower bridge, as shown at *a b*, is an insulated section of track. *1* and *2* are two trains. The passenger train *1* is in the block *X-A*, and is approaching tower *A*. As soon as train *1* entered this block it was announced to *A* by the man in the tower to the rear by four bells—"Passenger train has entered block." The track circuit at *X* dropped *A*'s card to "Train in block," as shown over instrument *3*, Fig. 5. (It will be noticed that the card

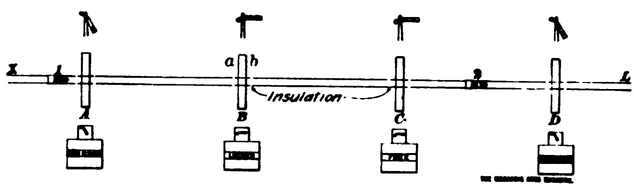


FIG. 6.

is not fully down.) *A* then asked *B* for an unlock by ringing three bells. *B* pulled out the brass handle on his instrument governing track *X-L*, and pushed it in again (called "plunging"). This made electrical connections, and thus raised *B*'s card to "Locked" (see instrument *2*, Fig. 5), that is, his instrument is locked, so that he cannot for the present give another unlock; it also dropped *A*'s miniature semaphore to clear, as shown at instrument *3*, Fig. 5. *A* has now received his unlock, and has pressed the button over his lever, as shown in Fig. 4, which made the final electrical connection, pulled his lever, and lowered his signal to clear.

Train *1* approaches block *A-B*. As soon as it strikes the insulated-track section at *A*, the miniature semaphore flies back to danger, and his card drops about ¼ inch, as shown at instrument *1*, Fig. 5. The track circuit also drops *B*'s card to "Train in block," first position. *A* now rings two bells to *X*, announcing that the train has cleared, and, as soon as it has passed his tower 400 yards, returns his signal to danger, and his card drops to "Free" (see instrument *4*, Fig. 5). If *A* should neglect to return his signal to danger, his card would remain at "Train in block," and he would be unable to give *X* an unlock for a following train. (Reference is made to different instruments only for the sake of illustration. These changes all take place in the instrument governing the particular track occupied by the train).

B asks and receives his unlock from *C* in the same manner as explained. After the train has entered block *B-C*, *C* asks *D* for an unlock; *D* refuses because train *2* has stopped in the block *C-D*; *C* is therefore unable to lower his signal, and train *1* is obliged to stop at *C* until the block *C-D* is clear.

The above is an explanation of the working of the system under ordinary conditions; it is known as an "absolute block system"—only one train in a block at a time. It becomes to an extent "permissive"—that is, trains are allowed to pass a danger signal under certain conditions, as follows:

1. When signalman is absent or disabled.
2. When the signal bell fails to ring. The tower man then gives the engineer a "Caution Card," duly dated and signed, stating that there has been no answer to bells. The engineer proceeds on his own responsibility to the next tower, where he must stop, ascertain the trouble, and report by wire to the division superintendent.
3. When a train is disabled in a block. The engineer on the following train is allowed to proceed with caution to the disabled train, and render assistance.
4. Failure of apparatus.
5. When a work train is in block.
6. Freights are forwarded with caution card on tracks *3* and *4* if the block is not clear at the expiration of 15 minutes after the preceding train has passed the tower.
7. In case of trains passing towers without "markers" (the flags or lamps on the rear coach, which indicate the end of the train), the signalmen in advance and rear are notified by the bell code. Thus, if *B*, Fig. 7, notices that a train passed him without markers, he notifies *A* and *C* by the code. *C* then displays a green-and-white signal, which notifies the approaching engineer that

his train has parted. *A* allows the following train to proceed with caution.

8. When train is backing off or crossing over.

It will be seen that the system on the passenger track is "permissive," only under abnormal conditions; and, so long as the engineer obeys the signals, collision is impossible.

In places where there are cross-overs, the towers are "interlocking"; that is, the levers are so interlocked that it is impossible to give a clear signal unless all switches are set in their proper positions for the passage of the train. This prevents a passenger train from rushing on to a shifting engine or on to a train standing in the depot. As these towers are complicated in their arrangement, it requires considerable experience to manipulate them, although the result of an error would merely be to stop the train.

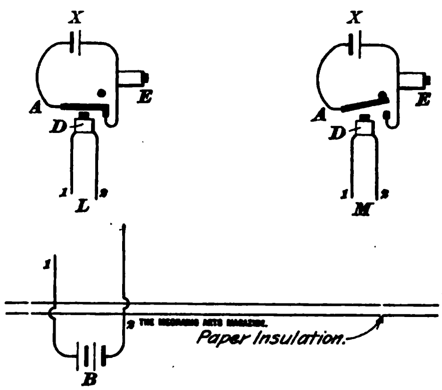


FIG. 7.

Each signalman is required to keep a record of the passage of the train, the time when rung in, the time of passing the tower, and the time of clearing the block. In these reports, the superintendent of signals for that division has a triplicate record of the passage of the train from one end of the division to the other.

The signal department is under the supervision of the assistant superintendent of signals of each division. He is in charge of the following corps of men: signal inspector, division electrician, electricians, batterymen, linemen, carpenters, painters, lampmen, and signalmen. On the main line of the New York Central there are 212 towers, placed at points varying from ½ mile to 5 miles apart.

To the outsider the system seems beautifully simple, both in conception and in operation, but its growth to the present stage of success has been the fruit of hard and persistent labor.

The object of its promoters is apparent. As a business investment, the system paid for itself in a short time, notwithstanding the enormous cost of installation and operation, and losses from accidents and damage suits have become a rarity compared with the experience of previous years. But this is not the only result sought or end attained. The efficiency of the system is such that the New York Central is enabled to run a far greater number of trains, at a much higher rate of speed, than would be possible without it, and the traveler who is whirled along at 60 or 70 miles per hour, with the assurance that he is as safe from accident as if he were on the ordinary trolley car, certainly ought to honor the brains and energy of the men who made such a thing possible, and who earned for the New York Central the reputation of being the best signaled road in the country, and who have, in conjunction with the manufacturers of improved rolling stock, and the inventors of safety appliances, made the luxury of American travel the talk of the world.

TOO MUCH ORIGINALITY.

THERE was once a young man who started out in life with the idea of being original. He wasted so much time in finding out for himself what other people could have told him, if he had only condescended to ask, that when he died he was away behind the times, and had accomplished nothing worth talking about.

In order to be original in a useful manner, it is not necessary to begin at the beginning "all by your lonesome"; it is better, in fact, to learn all that you can from others, to find out all that *has* been done in your line of work, to reap what others have sown, and then, and not till then, to attempt independence and originality.

IN THE WORKSHOP.

H. Rolfe.

A TROUBLESOME QUARTER-TURN BELT DRIVE—EVILS OF TOO MUCH CROWNING—AN OVERLOADED BELT—HOW SMOOTH A PULLEY FACE SHOULD BE.

MR. LOGSAW, the sawmill foreman of the G. S. Railroad, was in a bad temper. A certain large quarter-turn belt had been vexing his soul for some time, having developed a propensity for running off wheneverall the machines "got on" together. He had sent word to Mr. Blunt, the foreman fitter and millwright, and he, on ascertaining the facts of the case, had told one of his men—Plumb by name—to put larger pulleys on both shafts, and had also embraced the opportunity to tender the sawmill people, by proxy, a little fatherly advice on the proper way to treat a belt, laying special stress on the fact that a liberal use of the resin keg was only *one* way—and a very poor one, too—of dealing with a slipping belt. These remarks upset Logsaw, and at first he was inclined to go up and have it out with his confrère; he thought better of this, however, and went up to the docks instead, ostensibly to look up some mahogany logs, but really to vent his spleen on the timber-merchant's men; he knew they'd take it gracefully, for his Company was their best customer.

Plumb had been down to the mill with the new pulleys, and was ready for hanging them by the time the next meal hour had arrived, and reported that Logsaw had gone up town. So Blunt thought he'd step down and take a look at things for himself—preferring to do this during the absence of the enemy. He took with him Plumb's apprentice, Tom, partly because he was a relation of his, and partly because he liked to have an audience when airing his knowledge. The first thing that struck him "right between the eyes" was the state of the face of the driven pulley. It would have made a really good mirror.

"It's pretty evident," he said, "that that belt is overloaded; if there were no slipping, the face of that pulley would be a dull lead color; you can always tell by the appearance of the face how matters stand in that respect.

"In the next place, I see there is far too much 'crowning' to the pulley. Suppose you get a ladder, Tom, and measure how much there *is*."

"All right, sir," said Tom.

"Before you go up," said Blunt, "I'll show you how to do the measuring. I'll make a sketch of it. [See Fig. 1.] You can get the diameter d of the edge of the pulley by measuring the distance a with your foot-rule, multiplying this by 2, and adding the diameter of the shaft. To get diameter D, you'll want a large pair of calipers; deduct the belt thickness from the calipered distance, and you have it. Then half the difference between D and d is the amount of crowning."

"I can't do that," said Tom, "because I haven't a large enough pair of calipers; and I can't run a tape around, because the belt's in the way."

"Well," said Blunt, "never mind the diameter at all, then; get a piece of $\frac{3}{16}$-inch pin wire, and bend it to the curve of the rim, mark the shape off on something flat, and get at the crowning that way."

Tom did so, and found that the pulley had a full $\frac{1}{2}$ inch of crowning; that is, D was more than an inch larger than d; and the pulley was only $10\frac{1}{2}$ inches wide.

Blunt nearly had a fit over this; such an amount of crowning was too much for him.

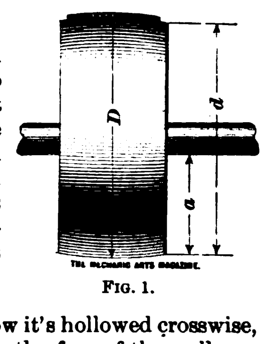


FIG. 1.

"Now look here, my lad," said he, "just you tell Plumb, from me, to either throw that thing into the cupola or else turn some of the crown off, ready for its next job. It's preposterous as it is now; the belt hasn't had a fair show at all; see how it's hollowed crosswise, trying to fit itself to the face of the pulley—and, by the way, it looks to me as if the driving pulley didn't have the same amount of crowning, for the belt seems to flatten out near the floor. Just go underneath, and bend your pin wire across the rim; and take the width too."

Tom did so, and found the face was 11 inches wide, and had only $\frac{1}{8}$ inch crown.

"There now," said Blunt, "just look at that! Why, the belt never had a chance. The pulley you've just measured is about right, but two pulleys that run together should always have the same curvature; so, although this driving pulley is all right in itself, it would really have been better, under the circumstances, if it had had the same crowning as the other one. As they are now, one is 'laughing at the other,' as an old foreman of mine used to say. If both pulleys had the same crown, the belt would gradually take that particular curve and remain so, thus obtaining good pulley contact. As it is here, it keeps on trying to adapt itself to each in turn, and can make only a poor show, at best."

"Perhaps," suggested Tom, "this driven pulley wasn't the one originally put up, but has been turned down by somebody who thought that, for a quarter-turn drive, more crowning was necessary. Certainly the belt seems to have a less straightforward job than in an ordinary drive, and I should think the tendency to leave the pulley was greater."

"Well, however that may be," said Blunt, "I have never made any difference in that respect between this and an ordinary drive. Right or wrong, such has been my practice. Anyway, tell Plumb to put on 48-inch and 32-inch pulleys, and to give them a full ¼-inch crown."

"Very well. By the way, sir, the larger pulleys will be quite a good deal easier on the belt, won't they?"

"Certainly; the pulleys, being four-thirds as large as before, the strain on the belt will be only three-fourths of what it is now—quite a consideration."

"I see. This morning," Tom went on, "one of the men was showing us a sketch of a *taper* belt that he once saw used on a quarter-turn. Plumb said he also had heard of them being used; and he explained to me afterwards that many schemes have been tried to help this kind of a drive. Once, he said, he tried a belt made up of three narrow ones side by side, connected at intervals by thin transverse strips; and this answered very well, but he thinks it would have done the trick much better if he had made the strips of unequal lengths, provided he got the *right* lengths."

"Well, I think that very likely; and it reminds me of a new belt that I saw advertised in this week's 'Engineer.' A quarter-turn belt, you must understand, hangs loose on the inside of the twist, which, therefore, does very little of the driving. Most of the work comes on the outer part of the belt; the wider the belt, the more noticeable this is. Well, the belt I saw advertised has a long edge and a short edge. The customer gives the maker the diameters of the driving and driven pulleys, and they make the belt to suit. It is claimed that the belt is just the thing for both quarter- and half-turn drives.

"But there's another kind of belt I want to tell you about, while we're discussing the subject, and that is a flexible-center link belt. This belt is particularly useful where

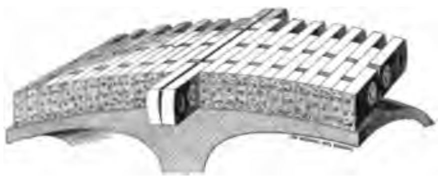


FIG. 2.

for any reason you *have* to connect two pulleys that have different crownings. It consists practically (as shown in Fig. 2) of two link-belts hinged together at the center in such a way as to permit a relative motion of the two halves. Suppose you had an engine with a flywheel whose face was perfectly flat, and you wished to drive a dynamo whose bandwheel was considerably crowned. Such a thing would be "rough" on an ordinary belt, and, considering the nature of the work, you ought to have the best connection obtainable. This belt would meet the case. It lies down to each pulley face in turn, without making any fuss about it."

"Yes, sir," said Tom, "I can see that. But now, with regard to these two pulleys here, isn't there any way of 'doctoring' them, and so saving the expense of two new ones?"

"Oh, yes; you might cover the driven pulley with leather; that would give the belt a better hold, and it would stand up to its work much better."

"But you said it was overloaded," interposed Tom.

"So it is—under present conditions. When the load on a belt reaches a certain point, the belt will either break, slip, or run off. Like most other things, it chooses the line of least resistance. In this case, it runs off. But this does not prove that, if *made* to stay on, it would not do the work. Well, covering the face with leather *makes* it stay on—up to a certain limit. Still, no amount of adhesion between pulley and belt will make the latter do more than a certain amount of

work, and from what I can see of this shop, when all these heavy machines are running at once, I judge that the belt is not equal to the demands made on it."

"Seems to me, sir, if you'll pardon my saying so, that there's some rank heresy knocking around here somewhere. You seem to be lamenting the fact that the pulley is *smooth*. Now, I thought a pulley ought to be as smooth as you can get it; what you say makes me think of the early locomotive men, who would insist on making the rail a rack, taking it for granted that the smooth rail wouldn't give the wheels 'bite' enough."

"Steady, my lad, steady! It should scarcely be necessary to tell you that it is not a good plan to work a belt up to anything like its full capacity; if you do, it certainly won't last long; it will have no margin to draw upon during emergencies. Therefore, the friction obtained with smooth pulleys, if the pulley diameters are judiciously chosen, is sufficient. Still the fact remains that, by increasing the friction between belt and pulley, you can get more work out of the same belt, and, where the load is subject to occasional heavy increases, such a proceeding is sometimes warranted.

"But," continued Blunt, "you don't seem to understand what I mean here by a 'smooth' surface. Look at a pewter teapot in a silversmith's window, and note its brilliant surface. That's what yonder pulley is like. Now expose that teapot to the weather for a week or two, and its surface will look like that of an old lead pipe; *that* is the kind of surface you want on your pulley—a dead-smooth surface. It isn't as beautiful to look at, I know, but it's a much better surface for belt driving, and is what we mean when we talk of a smooth pulley.

"In the present case, the trouble is that they have kept on putting down new machines, at intervals, but have left the driving gear as originally planned."

"Well," said Tom, "why not keep the pulley diameters as they are, but put up wider ones, and use a wider belt?"

"For two reasons. Belts cost money, and this one is about 45 feet long. If you merely put on larger pulleys, you'll only have to add a couple of feet, or so, to the length of the belt, whereas a wider belt will mean that you will still have to put on two new pulleys, and will have to pay for an entire new belt as well; you will also have the disadvantage of a wider belt—a thing to be avoided on a drive of this kind. So, although a leather covering is all right where the belt is up to its average load, but is occasionally overloaded, yet it is not to be recommended in the present case, for there would still be that excessive crowning present, and that alone is against the belt doing its proper work."

(*To be Continued.*)

DEVELOPMENTS, OR LAYOUTS.

D. C. Reusch.

THE DEVELOPMENT OF THE SURFACE OF A SOLID, CONSIDERED AS A ROLLING PROCESS—APPLICATION OF THE PROCESS—PRACTICAL EXAMPLES.

IN MANY branches of industry, a knowledge of how to develop the surface of a solid is very useful. By developing is here meant the unfolding, or laying out, of a curved surface, upon a flat surface, or, what is practically the same thing, the outlining of a flat sheet or plate in such a manner that, when bent or curved to constitute a solid, the latter shall be of the desired form and dimensions.

In the shops of boilermakers, tinsmiths, and sheet-metal workers generally, the ability to make such developments, or layouts, as they are usually termed, is called into requisition pretty nearly every day, and is a most useful accomplishment. Yet, somehow, the necessary knowledge is not very widespread, and is generally looked upon as difficult to acquire. The reason for this may be that the subject is too often treated merely as a branch of "projection, and the intersection of solids," and therefore, in reality, as the projection and intersection of *lines*. To ordinary practical men, this manner of treating the subject is of too abstract a nature and too difficult to grasp, because they are unable to see the reason and bearing of the various manipulations. The

writer believes that the more direct and tangible manner of treating the subject, which is here attempted, makes it much easier to grasp, and that it will be understood and appreciated by many to whom the subject is now a closed book; he also hopes that, although not as complete as might have been desired, it will still be sufficient to demonstrate the main idea, and be of some assistance to the practical man.

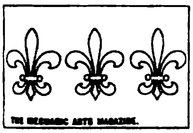


FIG. 1.

If a sheet of brass handsomely ornamented by means of perforations, as in Fig. 1, were handed to us, with instructions to reproduce it, or make a copy of it, we would not for one moment be at a loss what to do. We would either blacken its whole surface, and press it against a sheet of white paper, or else trace the outlines of the design by means of a pencil point; in either case taking what might be termed an imprint, or impression, of the plate.

Now, the whole art of obtaining the outline of a surface which encloses a solid body is nothing but the making of an imprint of said surface upon a sheet of paper. After once obtaining such an imprint, it should be an easy matter to cut it out and use it as a pattern for making any number of copies, either in sheets of iron, brass, cardboard, or any other material. When the pattern is bent into the required form, it should constitute an exact copy of the solid or hollow rigid body from which the imprint was taken.

But, the question may be asked, how make, upon a flat surface, an imprint of a

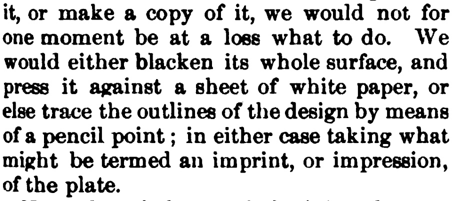


FIG. 2.

solid body, such, for instance, as a cylinder? The answer to this question is: If the whole surface cannot be traced at once, it may be possible to make a copy of it by means of a succession of imprints—in other words, *by rolling the body over the paper*. An example will make this clear: In Fig. 2 there is shown a cylinder *A*; it is desired to make, on the sheet of paper *P*, an imprint of the cylinder's curved surface. If a radius *a b* is marked on one of the end surfaces, and the cylinder covered with a thin coat of color, an imprint of the curved surface can be obtained in the following manner: Place the cylinder in the position indicated, that is, with the outer end *b* of the radius touch-

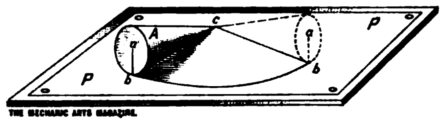


FIG. 3.

ing the paper, and roll it to the right until it has made one complete revolution, or until the radius *a b* again points vertically downwards, as shown in dotted lines.

If the body is a cone instead of a cylinder, its surface can be copied in a similar manner, but, while rolling, it will behave somewhat differently. Fig. 3 shows the shape of the surface traced by rolling the cone. To obtain it, proceed exactly as in the previous example, but notice that the cone traces a portion of a circular surface whose center is at *c*. Why this is so it is perhaps unnecessary to demonstrate here; yet a brief explanation may not be altogether out of place: Referring to Fig. 4, a shaft *a b* has rigidly connected to it a series of circular disks *1*, *2*, *3*, etc., the diameters of which decrease towards end *a* in such a manner that the general outline is a cone whose apex is *a*. The diameter of disk *6* is exactly half that of disk *1*; the former will therefore travel just half as far as the latter during one revolution of the shaft, while point *a*, being without measureable dimensions, will remain stationary. If, for the sake of argument, we now suppose that, while rolling over once, the disks travel along straight lines, the whole combination will eventually occupy the position *a 6′ 1′*, point *a* remaining stationary, and disk *1* traveling twice as far as disk *6*. But we see at once that the distances between *a* and *6′*, and *6′* and *1′*, are greater than distances *a 6*, *6 1*, which means that the disks had to *slide* upon the shaft *a b* to reach their new positions; this being impossible, we come to the conclusion that the only way in

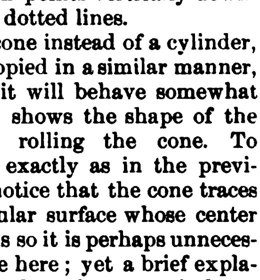


FIG. 4.

which the combination can roll, a remain stationary, and the original distances between the disks be unchanged, is for each disk to roll along the arc of a circle whose center is a.

We see the same conditions fulfilled when a line of soldiers turns a corner, the inside, or pivot, man remaining stationary, while the others, their steps increasing in length as

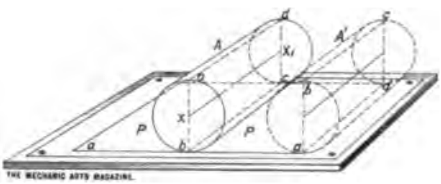


FIG. 5.

they are farther away from him, walk along circular arcs.

Referring again to the manipulations illustrated in Figs. 2 and 3, it may be said that the two bodies have simply been "skinned"; in other words, they were given an artificial skin, and this was left behind on the flat surface of the paper over which they were rolled.

This unrolling, or unfolding, of the surfaces of a solid or hollow rigid body is in reality all that the science of development consists of, and the various problems that present themselves in the workshop can generally be resolved into the unfolding of either a prism, cylinder, pyramid, cone, or some combination of them.

Looked at in this way, and with the object in front of us ready for "skinning," the whole thing appears rather simple; but when it comes to developing an object that has not yet been made, the surface of which has first to be laid out on paper, the process appears more complicated. Here, however, it should be remembered that, although in such a case we cannot take up the object bodily and perform the manipulations described, it is just as easy to draw upon paper the outline of the skin of the body, if we have but clearly in mind how we would proceed with the material body itself.

Let us begin with a simple case, and take a piece of pipe A, Fig. 5, 6 inches in diameter and 24 inches long. It is desired to find the dimensions of an iron plate which, when rolled into cylindrical form, will make a pipe of exactly the same dimensions. In this and succeeding examples, the additional length required for making the joint or seam is left out of consideration; in practice the allowance is made after the other dimensions have been found, and is a simple matter. It should also be noted that it is unnecessary to consider more than one-half of any symmetrical object; in this case, for example, the parts on either side of the diameter $a\ b$ are exactly alike, and only that on one side need be considered.

If, now, we imagine points a and b to be the extremities of a diameter of one end of the pipe, and lines $a\,d$ and $b\,c$ to be scribed along the surface parallel to the axis $X X_1$, we shall obtain other points d and c, also diametrically opposite each other. By placing a vertically above b, the line $b\,c$ will be in contact with the paper, and may be looked upon as the middle line of the cylindrical surface. If the cylinder is now rolled to the right, the line $a\,d$ will eventually come down upon the paper as indicated by the dotted cylinder A'. This line $a\,d$ upon the paper will then represent one end of the required plate; and, if we roll the cylinder back to its original position and then on to the left, the line $a\,d$ on A will again come in contact with the paper, and thus mark off the other end of the plate.

Of course this rolling of the cylinder is an imaginary process, all that we really wish to know being how far to the right and the left of $b\,c$ are the two lines $a\,d$ on the paper, which the cylinder, if actually rolled, would imprint.

Evidently the cylinder has made half a

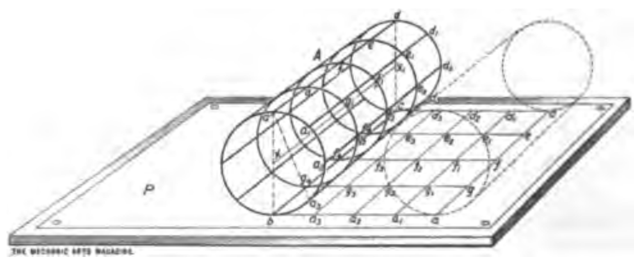


FIG. 6.

revolution by the time it reaches its extreme position to the right, and it is therefore only necessary to know the length of half the circumference of the circle $a\,b$ to enable us to make the required development, or layout. The whole circumference $=$ 6 in. $\times$ 3.1416 (3.1416 being the number by which the diameter of a circle must be multiplied to obtain the circumference) $=$ 18.85 inches; half this is 9.425 inches, which is, therefore,

the length of the line $b a$ as marked out by rolling the cylinder to the right. Rolling it to the left we get another $b a$, which is also 9.425 inches long. The total length of $a b a$ on the paper is therefore 9.425 in. $\times 2 = 18.85$ inches, and an iron plate 18.85 inches long by 24 inches wide will be sufficient to make the required pipe.

But how is it that the width of the plate is so easy to determine, while the length requires calculating? This is a simple question when dealing with a cylinder, but is nevertheless a matter of great importance. There is a difference between distances marked off *parallel* to the axis $X X_1$, and those marked off at *right angles* to it; to insure a complete understanding of this part of the subject, we will study Fig. 6. Here we have a skeleton cylinder built up of wires—longitudinal straight wires $a d$, $a_1 d_1$, etc., and circular hoops as shown. Now it is easy to see that, when the cylinder rolls, say, to the right, the imprints made by the longitudinal wires must be precisely equal in length to the wires themselves; and it is just as evident that the diameter $a b$ of the cylinder is considerably shorter than the distance $b a$ on the paper. This is because the cylinder has to make half a revolution before point a on the cylinder makes its imprint a on the paper, the distance $b a$ on the paper being equal to half the circumference of the cylinder. It follows from this that each of the imprinted distances $b a$, $g_4 g$, etc. must be much *longer* than the diameters of the wire hoops that produced them, and also that the lengths of the imprinted distances $a g$, $g f$, etc. between the hoops, are precisely *equal* to those of the wires that produce them. We come, then, to the conclusion that, while rolling either way, each of the hoops will imprint a straight line equal in length to half its circumference, and that the distances between any two of these imprints will be the same from end to end, and precisely equal in length to the actual distance between the hoops. It is evident also that the distance between any two of the straight wires, $a d$ and $a_3 d_3$, for instance, is not the same as the imprinted distance. In this case the actual distance between the wires is represented by the dotted line $a a_3$, and this is evidently shorter than the curved line $a a_1 a_2 a_3$. Whatever proportion the length of the curved wire $a a_1$ is of the circumference of the hoop, the same proportion will the imprinted distance $a a_1$ be of the line $b a$ on the paper.

In the case presented it will be noticed that the several straight wires divide the half surface of the cylinder into four equal parts, and that, consequently, the imprinted lines on the paper are also divided into four equal parts. The several lines on the imprinted rectangle $b c d a$ intersect one another at points by means of which any point on the curved surface of the cylinder can readily be located on the layouts. From this we see that, if the surface of a cylinder or other solid body is perforated with holes in various places, it is easy to find the actual distances between them, and then locate them on the layout.

(*To be Concluded in the April Number.*)

WHAT FIGURES MAY PROVE.

And Incidentally How Not to Make Use of Them.

IN THE October, 1898, number of the New York "Electrical Review," and under the above title, a prominent electrical engineer is represented as demonstrating, for the amusement of his friends, what a little mathematics is capable of doing. Those who can appreciate a joke will find both instruction and amusement in the following extracts:

"Give me juice enough, as we electrical people call it, and I'll make a gun which could be installed at Key West and land shells in Havana.

"You think that incredible? Not at all. Let's make a few figures. The range of a gun is determined by squaring the velocity in feet per second, multiplying by the sine and cosine of the angle of maximum range, and dividing by gravity; or, as the ordnance officers write it:

$$\text{Range in feet} = \frac{V^2 \times \sin a \cos a}{g},$$

which in simple arithmetic means, roughly, $V^2 \times .0155$, where V represents the muzzle velocity of the projectile.

"A gun giving a muzzle velocity of 2,000 feet per second has therefore a range of about 12 miles; while one giving a muzzle velocity of 6,000 feet per second would carry 108 miles. Of course, air friction would cut these ranges somewhat, but if I made a gun to give

a muzzle velocity of a little more than 6,000 feet per second in air, I could throw a projectile from Key West to Havana.

"This is of course beyond the power of any powder. Electrically, however, it can be done. All I want is a corking big long solenoid, built in sections, and the sections energized successively so as to pull on and continuously accelerate a core inside—the core being the shell itself. Do you see what a simple thing that amounts to? The shell would start very gently from a state of rest, and, suffering no shock whatever, could be filled with guncotton and provided with a percussion fuse.

"Now as to the energy required. This I have figured out by means of the very simple formula,

$$\text{Foot-pounds} = \frac{W \times V^2}{2g},$$

and I find it under certain assumed conditions to be 13,975,000 foot-pounds. Allowing 1 second of time for the shell to be acted on, this would mean 25,380 horsepower, and all that we would require electrically would be a current of 19,000 amperes at 1,000 volts. Nowadays we don't mind a little thing like that. The gun itself would have to be 1,500 feet long—a mere trifle.

"The cost of the power figured at the rate of $150 per horsepower per year, would be only 35 cents for the whole business, which beats any powder gun all to pieces. Now, you see, with a sufficiently lively automatic loading device, a torrent of shells could be spat out at the rate of 3,600 per hour."

Comment is perhaps unnecessary; a joke should never be explained. But we were asked a question the other day, the answer to which would be on a par with the above. It was: With a lever 10 feet long, attached to a nut upon a ½-inch screw, how much pressure could I obtain? Now, if this question were taken seriously and solved, it might be shown that a strong man could thus produce a pressure of one million pounds. But what would become of the miserable little ½-inch screw?

HARD WORDS AND SIMPLE IDEAS.

George McC. Robson, M. A.

Polarization of Light—Newton's Mistakes—Difficulties of Students—The Wave and the Emission Theory of Light—Influence of Emission Theory Still Felt.

THERE are many simple ideas that are commonly supposed to be very difficult to understand, whereas the difficulty is not in the idea but in the language in which it is expressed. The student who is beginning to study science finds no greater impediment to his progress than the habit that some scientific writers have of clouding the very simplest ideas in strange and formidable words, of which they give no sufficient explanation. Some of these writers fully merit the scathing censure bestowed upon Dr. Johnson in the following lines:

"I own I like not Johnson's turgid style,
That gives an inch the importance of a mile:
Casts of manure a wagon load around,
To raise a simple daisy from the ground;
Uplifts the club of Hercules—for what?
To crush a butterfly or brain a gnat;
Creates a whirlwind from the earth to draw
A goose's feather, or exalt a straw;
Sets wheels on wheels in motion—such a clatter—
To force up one poor nipperkin of water;
Bids oceans labor with tremendous roar,
To heave a cockle shell upon the shore;
Alike in every theme his pompous art,
Heaven's awful thunder, or a rumbling cart."

The greatest temptation that besets a beginner in any science is to acquire a habit of using the words which belong to the science without having any clear and definite conception of the ideas those words are intended to convey. It is to be feared that many students of physical science have given way to this temptation in regard to the words *polarity* and *polarization*, which are very extensively employed in physics—especially in connection with the phenomena of light. The words, however, have the same meaning, whether they are applied to the phenomena of light or to any other phenomena. In order to explain their meaning, it is simpler to consider first some phenomena not belonging to the science of light.

Take a violin string and pass it through a slit in a card, as shown in Fig. 1, making the slit a little wider than the diameter of the string, and stretch the string tightly. During all the experiments we are about to describe, the card must be held perpendicular to the string.

If the string is rubbed in the direction of its length, as indicated by the arrows in Fig. 1, it emits a piercing sound, due to the vibration of the particles of the string. In this case, each particle vibrates back and forth for a very short distance on each side of the

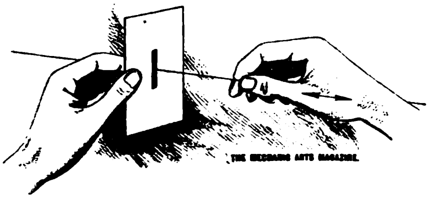


FIG. 1.

position it occupied before the string was rubbed, the direction of the vibration of each particle being along the length of the string. The vibration is passed on from one particle to another, and so a wave runs along the string from end to end. Thus the string is a medium which is transmitting a wave motion, the path of the wave being from end to end of the string. In this case the vibrations of each particle are to and fro along the path of the wave; such vibrations are called *longitudinal*. It will be found that the sound emitted by the string is unchanged no matter in what direction the slit is turned, provided the card is held perpendicular to the string. This proves that, while the string is vibrating in this manner, it has the same shape and condition on all sides; and the wave transmitted by it is said to be *non-polarized*. That is, by saying that the wave is not polarized, we simply mean that there is no difference of shape or condition between different sides of it.

When the string ceases to vibrate, take a violin bow and draw it across the string at

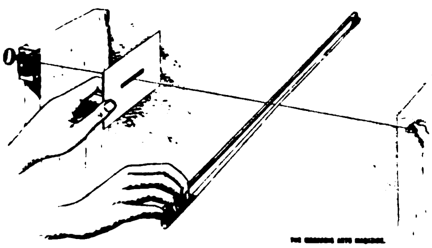


FIG. 2.

right angles to its length in the ordinary way, holding the card so that the slit is parallel to the bow, as in Fig. 2. The string is now thrown into vibrations and a wave runs along its length as before, but in this case each particle vibrates in a direction perpendicular to the length of the string. Vibrations, such as these, that are perpendicular to the path of the wave, are called *transverse* vibrations. The note emitted by the string when vibrating in this manner is not nearly so piercing as when made to vibrate by rubbing in the direction of its length. Now, if the card is turned till the slit is at right angles to its former position, and the bow used as before, it is found that the card interferes with the vibrations of the string and stops the sound, at least partially. This experiment proves that, while the string is vibrating in this manner, it has not the same shape and condition on all sides, and the wave transmitted by it is said to be *polarized*, or to possess *polarity*. That is, by saying that the wave is polarized, we mean that there is a difference of shape or condition between different sides of it. In this case, it is only when the slit is held parallel to the direction of the bow, when bowing the string, that the sound is not interfered with; it is evident, therefore, that the vibrations all take place in the plane containing the string and the line of the bow when bowing the string. When the vibrations are all in one plane the wave is said to be *plane polarized*.

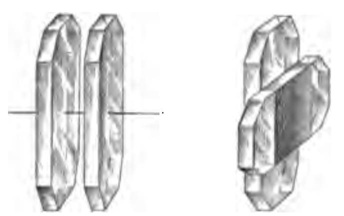
FIG. 3.

Let us now consider the vibrations of the ether which are the cause of the phenomena of light. The ether may be compared to a great mass of jelly. Suppose we turn out upon a dish a bowl of jelly, and insert in the center of it the head of a lady's hat pin, as in Fig. 3. If we move the pin vertically up and down, as indicated by the arrows, a quiver, radiating from the pin head, will run through the jelly. This quiver, or ripple, is like a light wave. As the ripple runs out radially and horizontally, the motion of each particle is up and down vertically—that is, transverse to the direction in which the wave travels. If we view one of the radial lines of this wave, looking down at it from above, each particle moves up and down, toward the eye and from it. If we view one of the radial lines of the wave horizontally, from one side, looking at the radial line perpendicularly, the motion of the particles is up and down, at right angles to the line of vision. This wave, then, presents different appearances on different sides; i. e., it is polarized.

But suppose the disturbance in the jelly to be caused by a small body consisting of innumerable little particles which are all in rapid vibration in all directions. Then the waves will radiate from the disturbing body in all directions. And, if we view one of the radial lines of this wave perpendicularly, it presents the same appearance, no matter what may be the position of our eye. Such a wave, therefore, is not polarized, and corresponds to the waves of ordinary light.

In the experiments with the violin string the polarization of the wave was detected by means of the card, which we therefore call the *analyzer;* the bow which compelled the string to vibrate in one plane and thereby polarize the wave, we call the *polarizer*. We shall now show that light-waves can be examined in an analogous manner.

Take two plates of tourmaline cut parallel to the axis of the crystal. When a ray of light is allowed to fall perpendicularly upon one of these plates, part of it is transmitted through the plate. To the eye the transmitted ray appears to be slightly colored,



(a) *(b)*

FIG. 4.

but presents no other noticeable peculiarity; a proper examination, however, will prove that the plate has acted as a polarizer, and that the light is polarized. To detect this polarization, we shall use the second plate of tourmaline as an analyzer. When the light transmitted by the first plate is allowed to fall perpendicularly upon the second plate, it is freely transmitted if the plates are parallel, as in Fig. 4 (a). If the second plate is rotated around the ray of light as an axis, the amount of light transmitted by it gradually diminishes; and, when it has been turned through a right angle, as in Fig. 4 (b), the light is entirely cut off. This experiment is a very simple one to perform; and any person who has not an opportunity to perform it himself will have no qualms of conscience about believing that those who have performed the experiment have correctly described the facts; it is the meaning and interpretation of the facts that causes the difficulty. Here our experiments with the violin string will help us.

Every one is familiar with the difference between a piece of wood cut across the grain and a piece cut along the grain. Now, the tourmaline plate has a formation somewhat analogous to the grain of wood, and this peculiar formation causes it to transmit easily vibrations which are in one direction, while it cuts off those vibrations which are in the direction perpendicular to those which it transmits. Thus, the ray of light transmitted by a single plate of tourmaline is not the same on all sides, but has acquired *polarity*, and is said to be *plane polarized* because its vibrations are all in one plane. The second plate enables us to detect the polarization of the light-wave, just as the card enabled us to detect the polarization of the wave in the violin string. This phenomenon is called polarization by *refraction*.

Light can also be polarized by reflection, but we shall not enter upon a discussion of this phenomenon. Our purpose at present is not to write a treatise on light, but to explain the very simple idea which is obscured a little by the tremendous words *polarization* and *polarity*.

This phenomenon of polarization of light is of the very highest historical interest. The wave theory of light was first propounded by Huygens in 1678; on the basis of his theory he was able to explain satisfactorily the laws of reflection and refraction; he was unable, however, to account for the rectilinear propagation of light or to explain the existence of shadows. About a century later the wave theory was revived by Dr. Young, who succeeded in explaining the fact that light travels in straight lines, and satisfactorily accounted for shadows by his beautiful theory of interference. Neither Young nor Huygens could explain the polarization of light in accordance with their theory, for they both assumed the vibrations to be longitudinal. The wave theory of light as proposed by the contemporaries of Newton was based on the assumption that light consists in a longitudinal vibration of the ether, just as sound is a longitudinal vibration of the air. Newton proved conclusively that this theory was incompatible with the observed facts of polarization. He therefore rejected the wave theory, and adopted the emission theory. This is one of those mistakes of Newton of which we hear a great deal, but if we study Newton's work we shall think less of his mistakes and be

more impressed with his transcendent genius, which is displayed more conspicuously, perhaps, in his "Opticks" than in any other part of his writings. The wave theory has now completely routed the emission theory, yet we must not suppose the emission theory is childish, or that the victory of the wave theory was an easy one. An adherent of the wave theory would require to be well grounded in the reasons for the faith that is in him before giving battle to an ingenious advocate of the emission theory.

Though the emission theory has been compelled to evacuate the territory, yet it has left many enduring monuments in the words which are still employed in the science of optics. For instance, the word *ray* is a relic of the emission theory, and properly has no place in the wave theory. When light was believed to consist of imponderable particles emanating from the luminous body and traveling with immense velocity in straight lines, it was natural and proper to speak of the path of one of these particles as a ray of light. The victorious wave theory, like other conquerors, has seized the possessions of its vanquished opponent and converted them to its own use. The word *ray* has been transferred from the vocabulary of the emission theory to that of the wave theory, and it may be well to explain what the word really means in the wave theory. If a pebble is dropped upon the surface of still water, ripples start from the point where the pebble falls and travel outwards over the surface of the water. It is observed that the crest of every ripple forms a continuous line, and the bottom of every depression also forms a continuous line. Each of these lines is called a *wave front*. In like manner, those particles in any ripple which are either all ascending or all descending, and are at equal distances from their mean positions, lie in a continuous line which is called a *wave front*. The wave we are considering is a plane wave, and therefore its wave fronts are lines. In general, a *wave front* is a surface such that all the particles on it at any moment are moving in the same manner and are at equal distances from their mean positions. In the wave theory a *ray* is defined as a line which at every point is perpendicular to the wave front which it intersects at that point. A military figure may serve as an illustration. In a regiment of soldiers marching straight ahead, the ranks of men correspond to wave fronts, and the files correspond to *rays*. The line of march is along the rays and perpendicular to the wave fronts.

ELECTRIC VEHICLES.

L. S. Levy.

DEVELOPMENT OF THE ELECTRIC VEHICLE—COMMERCIAL APPLICATIONS—DESCRIPTIONS OF VARIOUS CARRIAGES—FEATURES OF CONSTRUCTION RELATIVELY CONSIDERED.

THE world is ever on the look-out for novelties, yet it frequently happens that those which cause the most surprise are the very ones that have been in the experimental stage the longest. The electric vehicle, for instance, though it seems to have come upon us quite suddenly, is in reality the outgrowth of many years of experiment —not along exactly the same line, perhaps, but with self-propelled vehicles in general; and manufacturers of electric vehicles have profited by the experience of many; adopting the good points and avoiding the bad ones of automobiles of various kinds.

The great progress made in the substitution of electric for animal power on street railroads has long since removed all doubt concerning the practical efficiency of electrically driven vehicles. However, it is not the purpose of this article to discuss the broad question "horse versus electricity," but to explain the construction of electric vehicles in general, and their electrical equipment in particular.

The carriage shown in Fig. 1 represents the latest type of electric hansom for public service. It is perhaps more generally known than any other type—on account of its adoption by a New York concern incorporated to cater to the wants of the public—and has therefore been chosen for consideration here.

This cab is four-wheeled, as shown, and is driven by two motors geared to the forward axle. The motors are supplied with current by a battery of 48 cells of chloride accumulator, which are situated under the driver's

seat, behind the passenger compartment. The running gear is shown in Fig. 5, in which the arrangement of the various parts of the equipment is clearly shown. The motors *m*, one of which appears in the figure, are swung from the forward axle, as already stated, and transmit their power to that axle by means of an internal gear which meshes with the motor pinion. This method of mounting the motors keeps the distance between the centers of the two meshing gears constant, which is an essential condition.

It is evident that the motor for a vehicle intended as a means of conveyance over the public highway has to operate under unusually severe conditions, and therefore must be specially well constructed, and in every respect efficient. In the first place, it must be dust-proof and waterproof; it must also be capable of developing, during short intervals, two or three times its rated normal power, without showing any defects or weaknesses. These requirements apply to all classes of electric motors for vehicles. In the particular carriage under consideration, the motors are four-polar, of 2 horsepower each, with a speed, at 80 volts, of 700 revolutions a minute, the carriage then traveling at the rate of 12 miles an hour; they are iron-clad, are fitted with self-oiling bearings, are practically dust-proof, and have shown during tests some excellent results as regards current consumption, torque, and efficiency.

FIG. 1.

As already stated, the motors are supplied with current by 48 cells of chloride accumulator. Each cell has a capacity of 100 ampere hours at the normal discharge rate. Each is encased in a rubber jar, and consists of two positive and three negative plates, and weighs 26 pounds, making the total weight of the battery carried by each vehicle 1,248 pounds. The cells are placed on wooden trays, which fit into the battery compartment in the back of the vehicle, into which they can be inserted as a unit. When pushed into place the battery makes connection automatically with the motor and controller, by means of contact springs. The battery compartment is suitably lined, so as to prevent any spilled acid from attacking the woodwork, and is provided with channels to drain off the acid.

The total mileage, or length of run, on each charge of the battery will vary with the character of roads covered, as well as the speed with which the carriage is driven.

For the operation of the carriage a special controller has been devised. The speed variation is obtained by means of a division of the battery into two groups, which may be placed in series or in multiple, the third, or highest, speed variation being obtained by a rearrangement of the series field coils of the two motors from a series to a multiple combination. These variations are shown diagrammatically in Fig. 4.

FIG. 2.

FIG. 3.

The two groups of cells are shown as b and b', respectively. Armature a, in conjunction with fields f and f', constitutes one of the motors; and armature a', in conjunction with fields f'' and f''', constitutes the other motor. By using a separate reversing switch, the same speed or speeds can be attained in either direction; not that it is often desirable to run backwards at a high speed, but the connections provide for a large consumption of power in order to make a quick stop.

At the first speed, 6 miles per hour is attained, the two batteries being joined in parallel. From the positive pole the current divides itself between the two motors. In every case, each is series-wound, and from the diagram it is evident that the speed control is effected by series-parallel combinations. To proceed with the explanation begun above: The current on reaching, say, motor a, passes through both field coils in series, and then through the armature. At the second speed, the batteries are joined in series, the motor connections remaining as before. This combination gives to the carriage a speed of 9 miles an hour. When the controller is shifted to the third position, the field coils on the motors are connected in parallel, thus reducing the resistance of the field to one-quarter of its previous value, allowing a larger current to pass, and causing the drop in potential between the brushes to increase. The total field strength is, perhaps, slightly increased, but this is compensated for by the extra current through the armature. This, multiplied by the increased counter E. M. F., accounts for the increase in speed from 9 to 15 miles an hour, made by shifting the controller to the third position.

Besides having the controller handle within easy reach, the operator has at his hand a reversing switch. This switch is provided with an interlocking arrangement, which prevents the motors from being reversed until the controller circuit has been opened. The direct office of the reversing switch is to reverse the direction of the current through the armatures of the two motors. It is operated by the driver's foot, and is ordinarily in the "go-ahead" position.

There is, in addition to the above switches, an emergency switch for the purpose of instantly shutting off all current to the motors. This is under control of the operator's foot, a kick removing a key handle and opening the circuit. When this key has been removed, no outsider can turn on the current and cause a runaway. The brakes are applied by a foot-lever, and are double-acting, as shown in Fig. 5. This view of the carriage shows the various appliances described above, m being one of the motors. The controller handle is shown at c, and the brake lever at b; the latter communicates through suitable levers to the brake, which acts on a pulley mounted on the motor shaft. Steering is effected by means of the lever s,

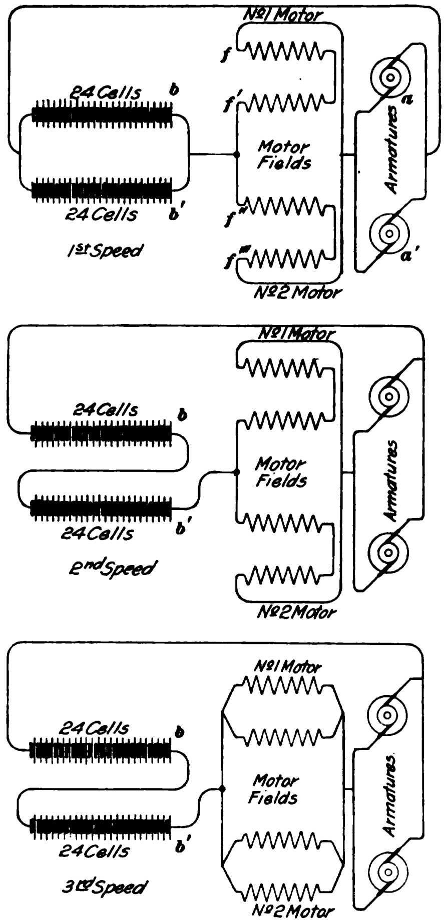


FIG. 4.

which swings the rear wheels; it is situated in front of the driver's seat, and is moved forward or backward.

As will be gathered from the above description, the vehicle is at all times under perfect control of the operator by reason of the ease with which all the controlling apparatus may be managed. This feature is common to all electric vehicles that have been placed on the market, whether for private or for

commercial use. The vehicles described constitute an excellent example of the latter class; but, when the former class is to be taken up, the field for description is extended.

In selecting the Columbia and Riker automobiles as examples of electric carriages for private use, we do not wish to discriminate against other vehicles of merit. These carriages can be, with justice, chosen as examples of the present stage of the art.

The Riker electric "Victoria," illustrated in Fig. 3, is modeled after the design of the horse-drawn vehicle of the same name. The light construction common in bicycles has been adopted in this vehicle. The body is specially built to carry the batteries, and to receive the controller, located under the seat, which governs the speed of the vehicle, running either forward or backward. A meter, for use in charging the battery, and located on the inner side of the dashboard, acts also as a guide from which the length of run remaining in the battery can be approximated. A foot-brake and an auxiliary hand-brake are provided, as are, also, electric side lights and an electric alarm bell. Under the cushion is a special Yale lock switch, by means of which, if the operator leaves his vehicle, and desires to guard against meddling, he may "lock" the current off. This vehicle is driven from the rear wheels, and is steered by the front wheels.

The double-seated carriage illustrated in Fig. 2 is a Columbia motor carriage made by the Pope Manufacturing Company, and is representative of their products in this line. It possesses many general features in common with other vehicles of the same class. The complete carriage battery consists of 44 cells, assembled in four separate boxes of 11 cells each. These four boxes can, by means of the controller, be connected either in multiple, two in multiple and two in series, or all four in series, thereby obtaining the three speeds, 3, 6, and 12.25 miles an hour. All speeds are for level roads. The motor is of a type designed particularly to obtain the maximum efficiency and capacity with the minimum of weight, and is especially capable of standing overloads. It is four-pole, series-wound, and designed for a normal load of 2 horsepower, at 75 volts, giving 1,000 revolutions per minute. The carriage is driven from the rear wheels, to which power is communicated through a

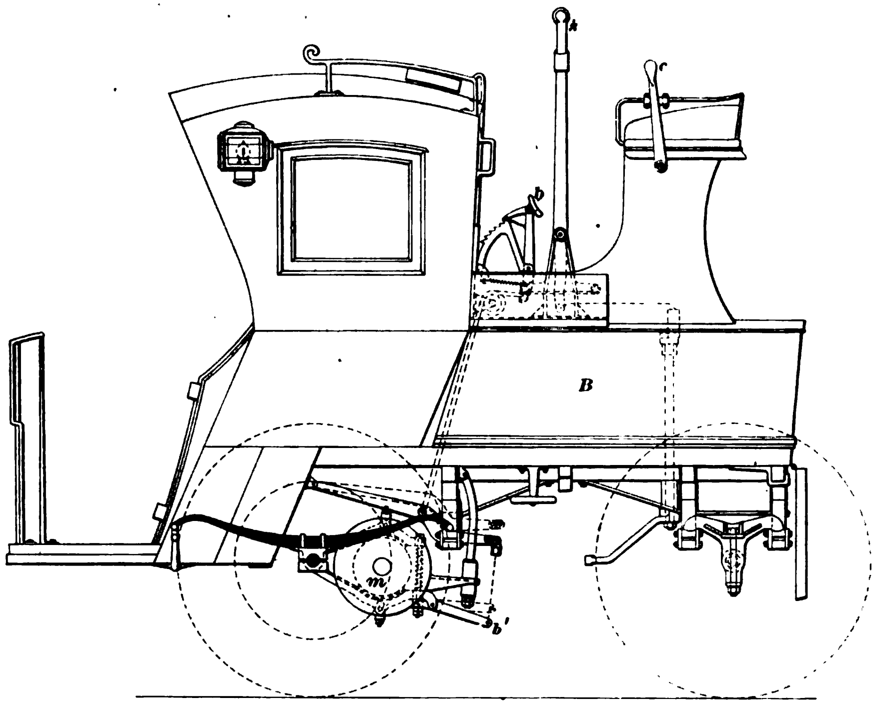


Fig. 5.

balance gear. By this means, when turning curves, one wheel automatically moves faster than the other, as is required. Steering and braking are accomplished much as in other vehicles, but the steering mechanism is of an unusual and unique type. Individual wheel steering is employed, the wheel pivots being slightly inclined, so that there is a tendency to maintain the wheels in a straight line, and render the operation of the steering lever comparatively easy. In turning curves the inside wheel receives a greater angular deviation, thereby relieving unnecessary strains in the wheels and tires.

All the vehicles described are equipped with pneumatic tires and ball bearings, thus giving ease of locomotion and requiring a minimum of attention.

While the electric carriage may not be the equal of the steam or petroleum automobile for hill climbing and extended use from centers of civilization, it is decidedly superior for the conditions under which ordinary pleasure vehicles are used.

SHOOTING STARS, OR METEORS.

Ernest K. Roden.

THEIR SUPPOSED ORIGIN, NUMBERS, AND AVERAGE SIZE—THE REASON FOR THEIR INCANDESCENCE—A GREAT PERIODIC SHOWER TO OCCUR THIS YEAR.

WHO has not seen, during a clear starlight night, the sudden appearance on the dark celestial vault of a brilliant streak of light, as one of those distant stars seemingly detaches itself, shoots in silence across the sky, then, as suddenly as it came, is again lost in the darkness?

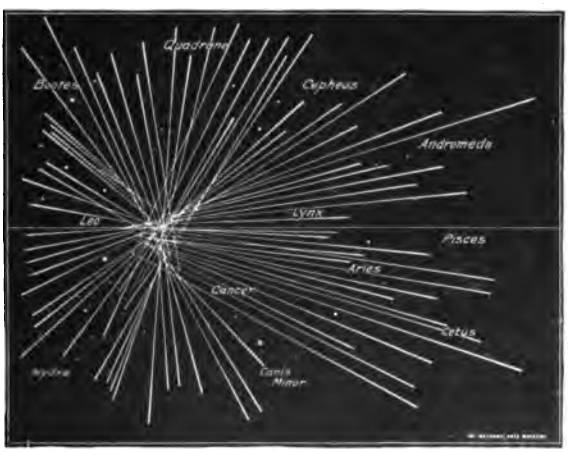


FIG. 1.—THE "RADIANT" OF A METEORIC SHOWER.

In ancient times all sorts of superstitious beliefs were connected with these shooting stars, and even today, the young maiden whose pensive gaze is attracted by the phenomenon hastens, from force of habit, to form a wish, with a hope of having it speedily granted; while the hypochondriac, with his ever gloomy view of things, believes it to mark the departure of a spirit to another world, or else to forebode the early passage to the same country of his own sad soul. Be all this as it may, these shooting stars—or *meteors*, as they are called—attract a great deal of attention, and give rise very naturally to many questions, such as, Where do they come from? Where do they go to? For what purpose do they exist?

The task of satisfactorily answering these queries would hardly be attempted by any one, however learned, our knowledge concerning these celestial visitors being very limited, and consisting in the main of theories.

Judging from the number of shooting stars that daily enter our atmosphere and, provided they are not caught by the attractive force of the earth, continue to circulate in elliptical orbits, and consequently to reappear at intervals, the total number in existence must be enormous. According to an estimate made by Sir Isaac Newton, the number that daily encounters the earth's atmosphere is between seven and eight millions. Their total weight, however, he estimated to be not more than one hundred tons; so that individually they are in general exceedingly minute.

Many people are apt to consider shooting

stars and meteors separately; in reality there are no real grounds for this distinction, their physical elements being in all probability identical, the only difference between them being in point of size; in this article the two names are used indiscriminately. Shooting stars have a curious and quite interesting history. They become visible to us only at the very last moment of their existence, the brilliant streak of light which indicates the path of a shooting star being, in truth, an evidence of its ignition and destruction. And how do they become ignited? This was for a long time a point in dispute, there being in the main two hypotheses advanced by scientists. The first was that the resistance of the atmosphere to a body dashing through it at the rate of about thirty miles a second generated sufficient heat to produce ignition; the second, that ignition was caused by the action of terrestrial magnetism. That eminent scientist, Sir John Herschel, clearly showed, however, that the first of these hypotheses was the correct one; that the air in the upper strata of the atmosphere is sufficiently dense to cause an enormous development of heat, when compressed in front of a body advancing at so great a velocity; and this opinion is still held in scientific circles. The meteor, or shooting star, then, in passing through the atmosphere, becomes incandescent, that is, white hot—the rapidity with which it reaches this temperature depending, of course, on the material of which it is composed; then, continuing its flight, its temperature is still further raised until the outer portion melts and is brushed off, by the resisting atmosphere, in the form of a long streamer, or tail, which, after losing its velocity, is precipitated to the earth as fine dust, resembling the ashes thrown out by a volcano. Meanwhile, the meteor, as it pursues its course, either becomes wholly dissipated and falls to the earth as above, or makes its way out beyond the limit of the atmosphere and proceeds upon its orbit through space. Thus a meteor may become visible and yet pass on without sending to the earth any evidence of its true character.

The speed of a meteor varies from seven to forty miles per second. Observations prove that the speed is about equal to that of comets descending toward the earth, and also that, like comets, meteors have orbits. It is scarcely possible for a shooting star of small size to reach the earth, for when, after rejoicing in the freedom of open space, the little body—weighing not more, perhaps, than a quarter of a pound—dashes into our atmosphere it experiences such a terrific resistance that, long before it reaches the lower and denser layers of air, it becomes so hot that it passes off in the form of vapor, and reaches the earth only as ferruginous dust. This dust is to be found everywhere, but especially on isolated mountains, in the polar snow, and in the products of deep-sea dredging. The Swedish naturalist Nordenskjold, when visiting Spitzbergen, melted several tons of snow; after filtering the water he detected in it a sediment containing minute globules of oxide and sulphide of iron, which in part constitute the ingredients of meteoric stones.

As a rule, shooting stars do not appear in like numbers night after night; in fact, there are certain daily, monthly, and yearly periods of recurrence of certain sets, or families, of them. About twice as many are seen in the morning as in the evening; this is because in the morning we are in the front of the earth in relation to its orbital motion, and consequently are able to see both the stars that we meet and those that we overtake; whereas in the evening we are in the rear of the earth and see only those that overtake us.

Upon certain occasions, great showers of shooting stars have been seen; the month of November seems to be particularly favored in this way. Observations made during the present century prove that meteors appear in great abundance on the evenings of the twelfth and thirteenth days of November; also, that there is an annual display about the middle of August or somewhat earlier. Their numbers vary considerably, however, when the apparitions of different years are compared. In some years they have appeared in great abundance, while in others their numbers have not exceeded those visible on ordinary nights. There are, however, several recorded apparitions of the November shower, separated in each instance by a wide interval of years. These displays, which have far exceeded in splendor those that have occurred either in November or any other month of any other year, have suggested the idea of a recurring cycle, distinguished by an extraordinary abundance of meteors; and it has been discovered that the interval between these grand displays is about thirty-three years. The explanation of this is as follows: From the known motion of the earth and the observed velocity and direction of meteors, it is demonstrated that they describe elliptical orbits about the

sun, and are therefore to be regarded as minute cometary bodies. Those that come in showers seem to belong to extensive groups, which revolve about the sun in zones. There appears to be several of these zones, whose planes are situated at different obliquities to the elliptic, and through which the earth passes once a year; when the earth passes through a more crowded part of such a zone, a meteoric shower occurs.

In 1833 a magnificent shower was observed, and a similar one was confidently predicted for 1866, that is, thirty-three years later. This prediction was splendidly confirmed. Another thirty-three years have now passed, and we have very good reason to believe that a grand shower will take place this very year, upon the evening of the thirteenth of November next. It is just possible, of course, that the shower will not come this year, but upon the same day next year; or it may occur on both occasions. Judging from the confirmations of previous predictions, however, there is little doubt that it will occur this year, as stated.

A gentleman who was traveling in South Carolina in 1833, describes the effect upon the negroes of the great meteoric display of that year: "I was suddenly awakened by the most distressing cries that ever fell upon my ears. Shrieks of horror and cries for mercy I could hear all around. While earnestly listening for the cause, I heard a faint voice close to my door calling for help and saying that the world was on fire. I arose and opened the door, when it was difficult to say which excited me the most—the distressing cries of the negroes or the awfulness of the celestial scene. Upwards of one hundred negroes lay prostrate on the ground, some speechless with terror, others with their hands raised, crying bitterly and praying for mercy. But above, the scene was truly awful; never did rain fall much thicker than the meteors fell that night."

FIG. 2.—A METEORIC SHOWER IN MID-OCEAN.

A peculiarly interesting feature of a meteoric shower is that all the meteors seem to diverge from a single point in the heavens, as indicated in Fig. 1, and this point—known by astronomers as the "radiant," or point of emanation—apparently keeps its position unchanged during the whole continuance of the shower. For the expected shower of next November, the radiant is

situated in the constellation of Leo ; for the August displays it is in that of Perseus. For this reason the shooting stars of November are frequently termed the *Leonides*, and those of August the *Perseids*. There are several other showers besides these, but they are of less brilliancy and duration.

A meteor which, on account of its larger size, is not dissipated and lost in the upper regions of the atmosphere, but falls to the earth, is called a *bolide*, or fireball. Such a body, during its flight through the air, resembles a globe of fire about as large, apparently, as the moon. On or immediately after its appearance, it generally produces an explosion, and sometimes even several successive explosions, which can be heard at great distances. There are numerous authentic records of bolides having been seen. They appear at all seasons of the year and are not confined to any particular portion of the earth, though most of the observations recorded have been made in Europe.

The astronomer Halley describes a fireball of extraordinary brilliancy which appeared over England one evening in 1719. It suddenly illuminated the streets of London, causing the stars to disappear, and the moon, which was at the time shining brightly, to become scarcely visible, and was so intensely brilliant that the eye could hardly bear to look at it. It moved like a falling star, at an estimated height of from 60 to 70 miles above the earth, with a velocity of from 300 to 350 miles a minute, finally exploding with a loud report.

From collected fragments of fallen meteors, it has been ascertained that they differ essentially from terrestrial rocks in that they invariably contain a large proportion of metallic iron. Nickel, chromium, tin, copper, and other substances have also been found in them, but it is a remarkable fact that no new element has been discovered in their composition.

As to the origin of meteors, very little is really known. They may be the product of eruptions from our own volcanoes, or from those on the moon or planets ; or they may be the fragments of a vanished world or worlds now scattered through space.

Whatever their origin and cause, when the facts known regarding them are compared, they seem to be all of the same nature and, perhaps, of similar origin, differing from one another mainly in the mere accidents of magnitude and density. The time for solving the problem is evidently far off—and possibly will never come at all—but whatever the solution, we know that they come to us from the depths of space, from distant splendors, and they prove that the substances and forces which surround us here exist also in other worlds.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Spanish-American Treaty.

THE war with Spain, which has been of paramount interest to this country during the past twelve months, began on April 21st, 1898. At the end of July it was evident to Spain that she was out-classed, and that further efforts on her part were futile. The French ambassador, M. Cambon, acting on her behalf, requested proposals of peace from the United States government. A protocol, or temporary agreement, was prepared by President McKinley, and on August 12th was accepted in the name of Spain by M. Cambon. This was a necessary preliminary to a formal treaty of peace between the United States and Spain, which should dispose of the cause of the war, and define the conditions imposed by the victor and accepted by the vanquished. From the date of its signature hostilities were suspended.

This protocol announced the conditions on which the president of the United States was willing, on behalf of the nation, to arrange and submit to the Senate for ratification a treaty of peace with the Spanish government. It was required that Spain should relinquish her sovereignty over Cuba; that Porto Rico and other specified islands should be ceded to the United States, who should also hold Manila until the future government of the Philippine Islands could be determined by treaty; that Spain should withdraw her troops from conquered territory; and that commissioners should meet

to negotiate a treaty on these lines. The commissioners appointed by the President were the Secretary of State, William R. Day, of Ohio; Senators Cushman C. Davis, of Minnesota, William P. Frye, of Maine, and George Gray, of Delaware; and Whitelaw Reid, the editor of a leading Republican newspaper. The Spanish government also appointed men of equal position, ability, and reputation. Two of them were members of the Senate; the others were a general who had had colonial experience, a diplomat, and a lawyer of distinction. As France had stood sponsor for Spain in the matter of the protocol it was natural to fix on Paris as the place of meeting for the commissioners, and the ambassador's quarters in the French Foreign Office were placed at their disposal.

Negotiations were begun with but little delay. The commissioners were in constant communication with Washington, and the president was consulted in connection with all important details. There was little discussion with regard to the abandonment of Cuba, over which the United States holds an indefinite protectorate; the cession of Porto Rico; or the withdrawal of Spanish troops from lands over which Spanish rule was to cease; the inevitable was accepted, for loss of territory almost always accompanies defeat in war. But there was grave difference of opinion with regard to the debt which Spain had incurred in connection with Cuba, and for which Cuban revenues were pledged. A part of the money had been spent in the island on public works of utility and defense; the larger proportion had been spent in the oppression of the Cubans, and in fighting them during their long struggle for independence. Spain insisted that the Cuban debt ought to go with Cuba. Other nations were interested in the decision of this question, for Cuban bonds are held elsewhere than in Spain, and every bondholder would prefer the security of the United States to that of the impoverished and almost bankrupt Spanish government. But the United States refused to accept any responsibility for this debt, or to allow it to be saddled on Cuba in the event of an independent government being established there; and Spain was forced to yield the point. Minor arrangements were settled with due formality and without much delay; political offenders and prisoners were to be given up; and the United States undertook to decide claims for damages against Spain on the part of American citizens. Stipulations were made with regard to the possession of military material, and the terms of future commercial intercourse between the two countries were arranged.

But the main cause of difference between victor and vanquished was the future of the Philippine Islands. The American commissioners laid claim to them as spoils of war, and asserted a right to decide what disposition should be made of them. The Spaniards denied that the islands had been conquered, as Manila, the only point effectively held by the Americans, had been seized after the signature of the protocol, by which act hostilities had been suspended. The wording of the protocol with regard to the Philippines was very indefinite, and Spain had ample ground for her opposition to American claims.

But the hard fact remained that she was helpless. If the protocol had demanded the cession of the Philippines as plainly as it did demand the cession of Porto Rico, Spain would have had no choice but to consent and sign. She had come to the end of her naval resources, and her troops could only have prolonged a hopeless struggle. Europe had watched the course of events, and knew that, as soon as Dewey's victory of May 1st had been won, the resolve that Spain should be expelled from the Philippines had taken root in this country, and that it had spread and strengthened, although opinions were divided as to American annexation and native independence. It was evident during the progress of the war that a part, at least, of Europe sympathized with Spain. Since assistance was not offered in her extremity we must conclude that a possible change in Philippine ownership was not believed to be of such vital consequence as to justify a combination against the superior strength of the United States and her British friends. As none came forward to help Spain to retain her Asiatic colonies at that juncture, while there was still a fighting chance, she could not expect aid after she had thrown up her hands.

Yet to the last Spain seems to have clung to the hope that influence would in some way be exerted in her behalf. It is difficult to account otherwise for her procrastination, and the prolonged arguments which were plainly futile. It was known that opinions were divided in the United States on the question as to the future of the islands, and that a strong party was opposed to annexation. It was also known that one of the commissioners indorsed this view. Perhaps Spain hoped that, under the influence of this opposition, the representatives of the

American people would modify their proposals, and that the sober second thought, for which the Spanish "manana" gave time, would be to their own advantage. From the point of view of the Spaniards, the American attitude towards Spain's ownership of the Philippines was much like that of Æsop's dog in the manger: "I do not want it, but you shall not have it!" She felt that European sentiment must be aroused by an act which bore the appearance of chastisement of a fallen enemy on the part of the United States, rather than the acceptance of an opportunity of desired territorial expansion.

But our commissioners became weary of the excessive delay in the execution of the treaty, and on November 21st they offered final proposals, demanding that an answer be given within a week. Spain had no choice but to yield on such terms as America chose to exact, and be thankful for the $20,000,000 which the victor offered as compensation for an island empire. She saw that further opposition was useless, and the treaty was signed under protest. The constitution of the United States requires that all treaties made with foreign countries by the president must be submitted to the Senate, and must be approved by two-thirds of the senators who are present when a vote is taken on the subject. The Spanish treaty came before the Senate on February 6th, and it was ratified by a very close vote. This narrow majority fairly represents the attitude of the country towards the Philippine question. Annexation in any form was opposed by many prominent and thoughtful politicians; others assented on grounds of expediency; while a large party, including many Western men, were ardently in its favor.

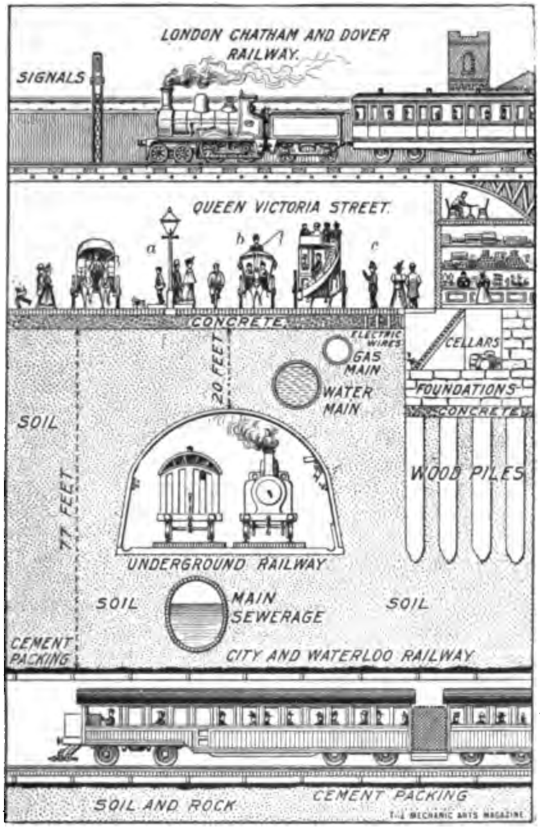
There is an old saying that "lookers-on see most of the game"; and to the European audience who have watched every move in this game of war the chief interest centers in the Philippines. Whatever may be the outcome of the present situation, this will rank in the future as the most important feature of the war—the one that involves the gravest consequences in national and international history. It matters comparatively little to the rest of the world that Spain has been banished from the American continent. The predominance of the United States was already established in the western hemisphere; and, if Cuba and Porto Rico alone be considered, the change in the balance of power is but slight. But the relation of the United States to Asia is of much consequence to European nations, of whom three are already Asiatic powers, and a fourth has shown that she means to follow the example of her neighbors.

Europe is no longer the stage on which the political drama of the civilized nations is played; the larger theater of the world is now its scene; and 1898 has seen America take her place as a permanent member of the company. From a people with such a history great things are expected if she puts her hand to a new task. It is still uncertain whether she will decide to rule her new possessions as colonies; if so, her experiments will be closely observed and criticized. Europe knows that such experience must be dearly bought; for Great Britain has demonstrated that successful colonial government demands long apprenticeship; but she has an inward conviction that America will believe the object to be worth the price.

Yet more important than the change which has been wrought in the relation between the United States and the other great world powers is the change which has manifested itself in the people as a nation. Granted that the desire for expansion is by no means universal, it yet has taken firm hold in the minds of men who will be the main factors in political power ten or twenty years hence. What seemed to be a chance seed fell on very receptive soil on May 1st, 1898; and its roots have shot deep and spread wide. The germ found awaiting it an environment well calculated for its development. The Anglo-American comes of a conquering race, and shares its imperial instincts. Whatever may be said as to the literal reading of the Constitution in connection with the acquisition of foreign territory, "for better, for worse," the old isolation has been broken down. The destiny of the Philippine Islands may be to become permanently subject to American rule, or to native rule, or to be made over—for a compensation—to the rule of some other power. In either case the voice of the American people will have spoken decisively in Asia; they cannot escape from the responsibility which events have thrust upon them. They will expect in the future to be heard, and other countries cannot reckon without them in the settlement of international affairs in that part of the globe. Whether or not America actually takes a place in the arena at this juncture as a colonial power, the thoughts that have stirred men's minds will not be forgotten; but sooner or later they will take shape in action; and no one knows what will be the end thereof.

THE BUSIEST SPOT ON EARTH.

WHERE is the busiest spot on earth? The mind of the New Yorker immediately reverts to Broadway and Fulton Street, while that of the average Londoner who knows the "city" will call up the space in front of the Mansion House, where—especially at noon, Saturday—many streams of traffic converge. Now, the above may be correct enough as regards surface traffic, but, when one goes *below* the surface, other places claim the distinction of being much busier. As all the traffic in New York is above ground, we must leave that city's busy spots out of the question and submit the claim of what is known as "Slaughter Corner" in London. Why this locality is so named we cannot say. Knowing the locality pretty well, we can assert that it is not one-tenth as dangerous to foot-passengers as a hundred other places that might be mentioned, although the artist, possibly to show the range of his powers, has depicted in the immediate foreground a specimen of nearly every kind of vehicle extant, together with a varied assortment of pedestrians.



The particular spot is about a minute's walk from the Middlesex end of Blackfriars' Bridge; the street is a business thoroughfare devoted largely to engineers' offices and showrooms—more particularly so, farther citywards. The artist has shown at *a* a street refuge, at *b* a "London gondola" (or hansom), and at *c* the harmless though necessary policeman with his eye on the traffic; the ubiquitous cyclist needs *no* pointing out. Crossing the bridge overhead is the London, Chatham & Dover Railway, sometimes irreverently spoken of as the "Bang 'em, Smash 'em, and Turn 'em over Railway"—not that it *does* any of these things, but because the Southern lines are in such disrepute with travelers that, if they *can* get even in any way, they do.

But it is not the visible traffic that gives this spot the right to its title; it is what goes on under ground. First, there are the electric-wire conduits; then the gas main; below that the water main; and farther down still the underground railway—the Metropolitan. This railroad, which was built in the early sixties, carries full-sized rolling stock and ordinary locomotives; the gauge is 4 ft. 8½ in., the same as American trunk lines. Immediately below this railroad the main sewage flows, and finally, 77 feet below the surface of the street, is a second underground railroad—the City & Waterloo—which is a quite modern affair, run by electricity. Taken altogether, it would probably be difficult to find another "slice of earth" that could hope to take from this the title it has earned.

STEPPING STONES IN THE ART OF COOKING.

Mrs. Henry Esmond.

STEP II: ROASTING, BROILING, AND BAKING; OR COOKING FOODS IN THEIR OWN JUICES.

TRUE roasting, that is, cooking in front of an open fire, is but little known in private families in America, what we call roast beef being in reality *baked*. In England, the kitchen ranges are made with a grate that is open in front—made so specially for roasting meats. The bars of this grate are horizontal and quite far apart, and the fire is raked to the front. From the wall above the range, there generally projects a spit, from which the meat is suspended and kept rotating in front of the fire. The meat is basted almost continually to keep the outside moist and to prevent it from burning.

In roasting, broiling, or baking any food, the radiated heat from the fire, or the heat of the air by which the food is surrounded, has very much the same effect that the heat of boiling water has upon food that is plunged into it, as explained last month; that is, it hardens the albumen, closes the pores, and prevents the escape of the juices.

Broiling is cooking directly over the clear fire, where the heat is intense. This method is specially suitable for steaks, chops, and fish, and for slices of meat of no great thickness. It is not suitable for joints of beef, or very thick pieces, because the heat is so intense that the outside would be burned long before the inside was even warmed through. The fire for broiling must be very hot and perfectly clear; smoke or blue flames will give the food a disagreeable taste. The meat should be turned frequently; this helps to keep the juices in, by causing them to run back and forth inside instead of running out. If the fire is not a very hot one, and you put the meat on to broil and fail to turn it over, the juices will rise and, escaping through the top surface, run over and be lost in the fire. Never attempt to do any broiling until you have a good, clear, hot fire. The time required to cook a good-sized steak 1½ inches thick, is about 6 minutes. Rub the bars of the broiler with a small piece of the fat of the meat; lay the meat on the broiler; hold it over the fire—about 4 inches above the coals—and count 10 seconds; turn the broiler, count 10, and repeat until the meat is done. If the melting fat, as it drips into the fire, blazes up, do not lift the broiler away, as the smoke from the burning fat flavors the meat agreeably. Do not put salt on the meat before cooking, as it draws out the juices.

Broiled chops should be simply well browned on both sides. Spring chickens should first be split down the back and sprinkled with flour, then broiled for from 15 to 20 minutes. Fish should be broiled for about the same length of time as a steak, or until it is well browned on both sides.

Baking is cooking in hot air; and, just as broiling must be done over a hot fire, so baking must be done in a hot oven, otherwise the juices—which are composed largely of water—will be evaporated, and the meat will become dry and tasteless. Have the oven very hot; place the meat in a dripping pan, without water or dripping of any kind; put the pan in the oven, and let it remain for from 10 to 15 minutes, or until the outside of the meat is seared; then add some butter, suet, or beef dripping, and a little water (not much water, or it will make the fat sputter) and baste the meat well with this; then dredge with a little flour; this forms a moist crust over the surface, which does not harden. After beginning to baste, the oven need not be kept at such an intense heat; a moderate oven is better, as too high a temperature will burn the fat before the inside of the meat is cooked. The time required to thus cook a rolled piece of beef is from 10 to 13 minutes to the pound; this should leave the meat pink and juicy without being too rare. Turkey and chicken require from 20 to 25 minutes to the pound. The same rules should be followed with them as with any other meat. Veal requires fully 20 minutes to the pound, and should be well done, or it is very indigestible.

In the baking of potatoes, the skin of the potato keeps the water in until the inside is cooked; then the starch cells burst, the water is converted into steam, and the skins should be broken so as to allow the steam to escape, otherwise the steam will condense inside the potato and make it soggy instead of dry and mealy.

GOOD SCHEMES

A USEFUL PIECE OF GLASS.

Templet, New York, N. Y.

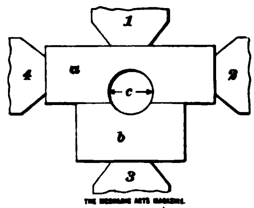
WHEN FILING up templets, worm-thread tools, certain forms of cutters, etc., I have found a piece of glass, used as indicated in the accompanying sketch, a great help.

Without the aid of some guide, it is almost impossible to hold the templet square with the work; but if a piece of sheet glass *c* is held against both templet *a* and work *b*, the trick is done, and the fit of the parts can be compared by holding up to the light and looking through.

A CENTERING AND CHUCKING DEVICE.

Interested Reader, Waukegan, Ill.

SOME TIME ago I had several small center reamers to make on an ordinary lathe. Of course I roughed them all out, and finished them "all except bringing them to the correct taper" on the lathe centers. Then I had to hold them by the shank and finish them, the compound rest being set to cut the proper taper. Now the shanks were too small to be held in the chuck; besides, it would have been tedious work getting each to run dead true. This is what I did: I took two pieces of steel, one considerably shorter than the other, as at *a* and *b* in the sketch. The long piece I held between the three jaws *1*, *2*, and *4*. Then, by means of jaw *3*, I fixed the shorter piece up against the longer one, with a strip of thin sheet tin between the two. Next I drilled hole *c* exactly the same diameter as that of the shanks to be held. On loosening jaw *3*

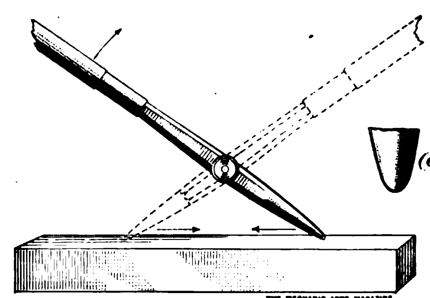


and removing the ends of the strip of tin, I found that I had a most satisfactory centering and chucking device; all that I had to do to secure the work was to tighten up jaw *3*; and, of course, loosening this same jaw released the work.

TO DRESS A RULING PEN.

Ralph F. Kiefer, Sharon, Pa.

THE FOLLOWING directions for dressing the blades of a ruling- or a bow-pen will, I think, be of use to draftsmen: Screw the blades into contact, and pass them over an oilstone, as indicated in the illustration, turning them



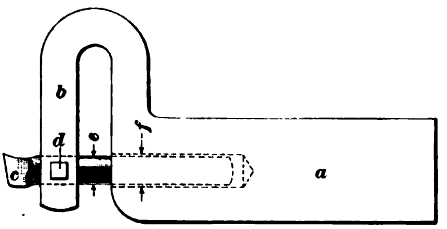
in a plane directly perpendicular to the face of the stone until both blades are the same in outline, and are of the shape shown at (*a*). Unscrew and examine. You will find that

the blades are of unequal thicknesses around the point. Taking now one blade at a time, wear the backs down carefully on the oil-stone until the edge of each is even and keen. Screw them together again, and pass carefully and lightly over the stone, to correct any visible faults. Now unscrew, open wide, and, laying the inside face of each blade flat on the stone, remove the burrs. Finally, to get rid of all adhering particles, draw each blade two or three times across the palm of the hand.

A USEFUL LATHE TOOL.

Prentice, Canada.

I ENCLOSE sketch of a lathe tool which I have found useful for cutting the grooves in the rings that secure the steel tires to the wheels of a locomotive; I refer to the rings that prevent a broken tire from flying off in pieces. The tool is also far ahead of a solid square-nose, or parting tool, for cutting off disks of wrought iron or steel, and for cutting into work at right angles to the lathe face-plate or chuck. It consists of a tool-steel tool holder *a*, having bent part *b* through which the cutting tool *c* is inserted; this cutting tool, which I made of $\frac{1}{2}$-inch round

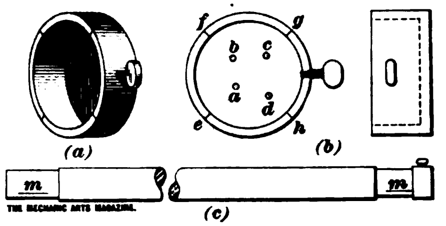


tool steel, is a snug fit in the hole in *b*; and is secured from turning by the setscrew *d*, but is a loose fit in *a*—diameter *f* being about $\frac{3}{64}$ of an inch larger than diameter *e*; this allows *b*, and with it the cutting tool, to spring. In proof of its usefulness, I may say that when I am not using it myself it is frequently borrowed and used by others.

AN ECCENTRIC CENTERING JIG.

Workman, Cincinnati, Ohio.

IN THE SHOP where I am employed, there are a great many eccentric shafts to turn. To quickly and accurately center these shafts for the required throw, I made the jig illustrated at (*a*) and (*b*). The old way of marking off occupied a great deal of time, most of which is saved by using this jig. The holes *a*, *b*, *c*, and *d* are at different distances from the center, the same jig thus answering for four different eccentric throws. Four fine radial lines *e*, *f*, *g*, and *h* are cut across the rim, as shown, one for each of the holes. The jig is used in the following manner:

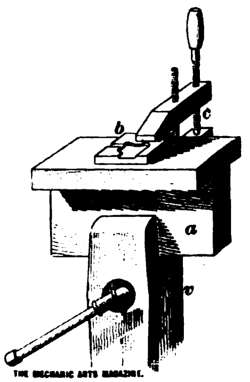


The ends of the shaft are turned to fit the jig, as at (*c*). Then, while still in the lathe, a fine line *m* is made at each end; this is done with an ordinary lathe tool by traversing the carriage, the shaft being rigidly held from turning. The shaft is then taken to the drill press, the jig placed on one end so that one of the radial lines *e*, *f*, *g*, *h* coincides exactly with line *m*, and secured with the thumbscrew. The desired center hole is then drilled through the jig into the end of the shaft. The same thing is done with the other end, using the same line on the jig to match line *m* on the shaft.

A VISE ATTACHMENT.

Ed. J. Roy, Belleville, Ont.

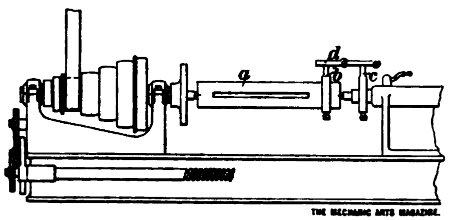
I FREQUENTLY make use of the following easy way of holding small patterns and core boxes, instead of squeezing them between the clumsy jaws of the ordinary patternmaker's vise: *a* is a T board, which is held in the vise as shown; then, by means of the hand screw *c*, the piece *b* to be operated upon can easily be held in any desired position. Sometimes it is advisable to use two hand screws, one to hold the work down, the other to clamp firmly to the top of the T board itself, to act as a stop—in other words, to push the work against. Delicate patterns can easily and safely be carved out when held in this manner.



PLANING IN A LATHE.

R. Hampson, Armiston, Alabama.

IN A RECENT number of your magazine a subscriber asked if you knew of any way in which planing could be done in a lathe. In reply, you suggested that some interested reader might send an answer as a contribution to "Good Schemes." The sketch herewith shows how I have successfully planed keyways in a lathe. Referring to the figure, *a* is a shaft in which a keyway is to be planed. I first drill or otherwise cut a place at each end of what is finally to be the keyway, for the cutting tool to start and stop in. Then I clamp the shaft to the tail-stock by means of clamps *b*, *c*, and *d*; secure the proper tool in the tool post; put in change gears as if I wished to cut a very coarse screw thread; drop in the back gears; run at a high speed;



and thus obtain a quick traverse of the cutting tool.

Keyways or slots can be cut inside cylinders by using a fixed boring bar and clamping the work to the carriage. Taps and reamers can be fluted by clamping to the tail-stock and traversing the carriage by hand.

CALIPER SETTING.

C. C., Ottumwa, Iowa.

I BELIEVE it is a fact that the beginner always finds it difficult to so set his calipers for lathe work as to get, at will, a driving fit, a snug fit, or an easy fit. Of course, nothing but experience will tell a man just how many thousandths larger or smaller a shaft must be to insure the desired fit, but one can learn a good deal by experimenting with various thicknesses of paper. For example, if it is desired to turn up a shaft so that it will be a driving fit in a gear-wheel, proceed as follows: Caliper the hole in the gear with inside calipers, as usual; then, when transferring this measurement to the outside calipers, hold one or more thicknesses of paper over one of the points of the inside calipers, so as to increase the measurement by the required amount. The paper should be smooth and hard, and its thickness must be known. Where micrometer calipers are not at hand, this scheme will be found a great help. After long practice the "feel" of the calipers on the work is sufficient guide, but I believe the above method will teach the beginner to set his calipers properly and with a little practice to "feel" accurately to a thousandth of an inch.

TO MOUNT A PHOTOGRAPH.

Kodaker.

I HAD NOT been an amateur photographer very long before I discovered that it was no easy matter to mount a print both central and square on the card. This led me to take particular notice of the work done by my numerous brothers in art, and I found, to my surprise, that my work in this direction was as good as, and, not seldom, even better than, that done by much older hands than I. This discovery set me thinking, and I thought out and have since used, with never-failing success, the following scheme: With a sharp knife and the help of a couple of celluloid set squares, I trim the print to the required size, and thus get the corners square and the edges perfectly straight and smooth. Then I hold the print under the cold-water faucet and, when evenly wet, lay it, face down, on the glass. To the back of the print I now apply the paste, and rub it in well with a fairly stiff brush; then I make a careful examination of the pasted surface, and remove any little lumps or particles of dust, however minute, that I may find upon it. Slipping the blade of a pocket knife under one corner of the print, I now take it off the glass and lay it—still face down—upon a piece of *transparent oiled silk* previously dampened with a wet sponge; it is this piece of oiled silk that does the trick; being damp on the surface, the print adheres to it, and, being transparent, when held (with its adhering print underneath) in a horizontal position over the mounting card, you can lay the print down wherever you want it, and, if you have anything like a true eye, you have no difficulty in placing it exactly in the center of and square on the card. I used to be ashamed of my mounting; now, I'm proud of it.

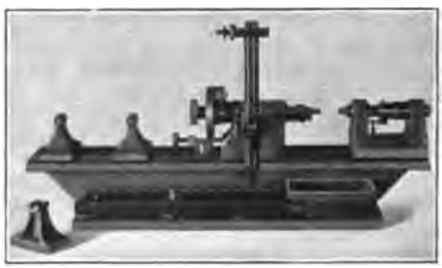
TRADE NOTES

A NEW MEASURING MACHINE.

In the January number of this magazine, there appeared an article entitled "One-Millionth of an Inch," in which a machine for detecting an error of one-millionth of an inch was described. The illustrations on this page represent the New Model Standard Measuring Machine, manufactured by the

Front View.

Pratt & Whitney Co., Hartford, Conn. While advising us of the successful introduction of this machine, the makers take the opportunity of stating that though the Whitworth machine, described in the article referred to above, is no doubt capable of detecting a very small *error*, it is not possible for it to *measure* anything like so small a length as it was designed for, except on the assumption that each detail of its construction is perfect within that limit; and it is well known that it is impossible to produce a screw, or any other piece, within a limit ten times greater than one-millionth of an inch. The makers claim, and we have every reason to believe them, that the New Model will positively measure a definite length within a variation of one hundred-thousandth, or .00001, of an inch; this amount, it is generally acknowledged, is the practical limit of exact reproduction. The New Model is described as an instrument of precision for originating gauge sizes, or for duplicating existing standards, within limits that are necessary and practicable for this class of work. The bed is massive, the object being to secure the greatest possible stiffness combined with the necessary weight; it is supported on three neutral points, or feet of small area, hence is not affected by sudden changes of temperature or by flexure. The sliding head, which includes the precision screw and index, is carefully fitted upon the ways of the bed, to secure parallelism of the measuring faces at any position, up to the capacity of each size of machine. The screw has adjustments for compensation for wear in nut and shoulders. Delicacy of contact between the measuring faces is obtained by the use of auxiliary jaws holding a small hardened cylindrical gauge between them by the pressure of a light helical spring which operates the sliding spindle in the left-hand head, to which head one of these auxiliary jaws is attached. The behavior of this "sensitive piece"—shown at *a* in front view—readily determines the uniformity of contact



Rear View.

of the measuring faces at zero and upon the gauge which is afterwards measured between them. The rear view shows the standard bar *b*. The sliding micrometer head of the machine is adjusted by the coincidence of a single line in the eyepiece of the microscope with each finely ruled gradation of this standard bar.

A UNIQUE OFFER.

On looking through the advertising pages of a popular magazine or periodical, it is no unusual thing to find what appears to be a remarkably generous offer by some well known manufacturer or dealer. Publishers of historical and literary libraries, for instance,

offer to send valuable sets of books, to be returned if not approved, or, if satisfactory, to be paid for at the rate of a paltry sum per month. There was a time, and not so long ago either, when all such offers were looked upon with suspicion; but now, the very fact that the advertisements appear in journals of repute stamps them as bona fide. One of the latest and most striking offers of the kind is made by Messrs. Cornish & Co., Washington, N. J. This firm, whose plant and property is estimated to be worth over one million dollars, and who, during the fifty years they have been in business, have had upwards of 250,000 patrons, offer to ship a piano or organ anywhere, upon the distinct understanding that, if it is not satisfactory to the purchaser after twelve months' use, they will take it back. It is perhaps needless to say that the manufacturers have the best of reasons to believe that their instruments will give general satisfaction, or they would not make an offer of this kind. The most recent improvement and addition to the Cornish American piano is the instrumental or orchestral attachment, which enables any ordinary player to accurately imitate the tones of the mandolin, harp, guitar, dulcimer, banjo, and zither. Any one of these tones is obtained by simple foot pressure on the pedal controlling it.

AN IMPROVED PNEUMATIC HAMMER.

The F. C. Austin Mfg. Co., Harvey, Ill., tell us that they are making an improved pneumatic hammer, which by reason of the following points is very effective in its work: The hammer is valveless; the air is let directly onto the piston; by this direct application of the air, a very heavy blow can be struck, or it can immediately be regulated to suit the work; no hole or port is smaller than the main ports. With this hammer, from 3,000 to 4,000 clean, free blows per minute can be struck without jarring the operator.

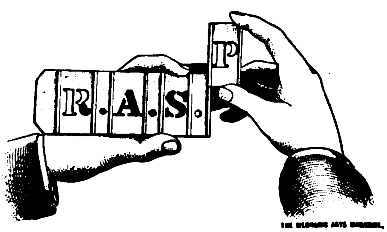
A MICROSCOPE FOR AMATEURS.

It is probable that, during their spare time, the majority of the readers of this magazine ride some hobby, from which they obtain both amusement and instruction. It is also probable that to some the study of the microscope is not altogether unknown; but it is a fact that the great cost of a good microscope has hitherto kept many from enjoying the invisible world about them, just as formerly the cost of the camera and lenses, and the tedious process of picture making, confined photography to the professional. Thanks, however, to the Bausch & Lomb Optical Company, of Rochester, N. Y., it is now possible for any one to become possessor of a really accurate and suitable instrument. The outfit which, for $16.00, this well known firm is prepared to supply, consists of the "Practical Microscope," with one eyepiece and with divisible objective—giving powers of 53 diameters (2,809 times) and 180 diameters (32,400 times), together with an entire outfit for work, two excellent books of instruction, and twelve different permanently prepared objects of general interest; a magnified picture of one of these is reproduced here. The Bausch & Lomb Company will mail, on request, any of their catalogues, and will be glad to give whatever information is desired.

BUTTERFLIES' EGGS.

AN IMPROVED LOCK STENCIL.

F. A. Sackman, 34 Prospect St., Cleveland, Ohio, has issued a new catalogue of his steel stamps, stencils, burning brands, check punches, key and baggage checks. The illustration represents improved interchangeable "lock" stencils, which are made in five sizes, from ½-inch to 2½-inch letters.



A NEW PUBLICATION.

"Graphite" is the name of a new publication issued, as the first number explains, in the interest of Dixon's graphite productions, and for the purpose of establishing a better understanding in regard to the different forms of graphite and their respective uses. It is published by the Joseph Dixon Crucible Co., Jersey City, N. J. We may add that

this very enterprising firm has lately distributed a pamphlet entitled "Pencilings," which should be of considerable practical value to artist and draftsman alike. In addition to information on how to decide what grade of pencil to buy, there are some useful hints to artists on the employment of colored pencils in sketch-book work, in which it is urged that where it is desired to record the colors of, say, a landscape, it is better to do so by using colored pencils in making the sketch itself, than by making voluminous notes on an ordinary pencil sketch.

BOOKS AND CATALOGUES.

POCKET BOOK FOR MECHANICS. By Peter Lobben. Published by Scandinavens Boch, Chicago, Ill. Price $2.00.

The copy before us is in Norwegian, but we understand the translation into English is already in the printer's hands. There are doubtless many, however, to whom the original will be welcome. The author states in his introduction that the book is written for practical men who are not satisfied with merely *doing* a thing, but wish to know *why* it is done as it is. It contains a comprehensive treatise on arithmetic, tables of logarithms, geometric constructions frequently met with in workshops and drafting rooms, a treatise on strength of materials, theoretical mechanics, and machine design. All of the most important tables are given in metric as well as in English measurements.

AIR BRAKE CATECHISM. By Robert H. Blackall, Air-Brake Instructor and Inspector of the Delaware & Hudson Canal Company Railroad. Cloth, 240 pages. Published by Norman W. Henley & Co., New York. Price $1.50.

This book contains a complete study of all parts of the air-brake equipment, including the latest devices and inventions in use. The various parts of the air-brake system are taken in logical order, and their purpose and mode of working fully explained. The peculiarities and "troubles" of every part are dwelt upon, and—what is of great practical value—a good way to locate and remedy each trouble is given. The whole subject is presented on the "question-and-answer" plan, as the best adapted to beginners. But the book will prove of great value to advanced students also, as it treats not only the simpler problems but the more intricate ones as well. There are a number of very excellent illustrations which include two handsome folding plates—one representing the general arrangement of the Westinghouse quick-action automatic brake on an engine, tender, and passenger car; the other, the 9½-inch improved air pump.

ADVANCED METAL WORK. Part I—The Speed Lathe. By Alfred G. Compton and James H. DeGroodt. John Wiley & Sons, New York, publishers. Price $1.50.

This little volume is the first installment of a series of three books on advanced metal work, following up a former publication by Prof. Compton, entitled, "First Lessons in Metal Working." To do justice to the book it must be taken for what it is meant to be. It is intended for the use of technical schools, manual training schools, and amateurs, as a means of furnishing explicit directions without dispensing with the watchful eye and helpful hand of an instructor. It contains in 13 "Lessons" about 50 exercises to be performed on the speed lathe in turning wood and brass, and in spinning. As the author states in the preface, the course pursued in the book is the same as followed for years in the workshop of the College of the City of New York. The book contains all that the title and preface indicate, and will fulfil its purpose well. It is to be regretted, however, that the illustrations are below even the average in execution.

STEAM, GAS, AND OIL ENGINES is the title of a book of considerable interest to engineers, which will be published this spring by the Macmillan Company. The author, Professor John Perry, has prepared this book in a very exhaustive way, so that not only will it be of use to those with technical knowledge and skill, but it will also be of value in helping manufacturers and owners of office buildings, in their selection of the most suitable and serviceable plant.

THE SYRACUSE SUPPLY CO., LTD., Syracuse, N. Y., have handed us a copy of their latest catalogue, a handsome, cloth-bound, 450-page, 8″ × 6″ book, in which are illustrated and described machinery, tools, and supplies for machinists, engineers, blacksmiths, model makers, foundries, molders, inventors, amateurs, and all users of power. The contents, which are carefully classified and arranged for the convenience of the intending purchaser, include much information concerning the use of the various tools and devices catalogued, which gives the book an intrinsic value to every manufacturer or mechanic.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(35) Is the answer to question No. 539 in HOME STUDY MAGAZINE, January, 1899, correct? You say that in walking around the post the man walks around everything that is on the post. From this I might argue that a point in the rim of a carriage wheel travels around the hub of the wheel; for the point travels around the axle, and the hub is on the axle; therefore, the rim travels around the hub.

M. L. S., Guadalajara, Mexico.

ANS.—The answer as given in the January number is correct. It was not intended, however, as a general statement, and we do not see that you have any reasonable excuse for taking it as such. It is not true that a man who walks around a pillar walks at the same time around the building which the pillar happens to support. The *rim* of the wheel you mention does not travel around the hub, any more than you walk around your nose every time you happen to turn around on your feet. You are quite justified, however, in arguing that a *point* in the rim travels around the hub; but a point has no substance, so you gain nothing by the argument. The whole question is rather of the nature of a catch, and the correct answer to it depends upon your individual opinion of what "walking around a thing" really means. If you consider it necessary to *see all sides* of the object, then it would be impossible for you to walk around anything with your back turned towards it, or for a blind man to walk around it at all.

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(36) (*a*) Is there such a thing as an X-ray burn? If so, what is the cause of it? (*b*) Would X-rays from static machines produce such a burn? (*c*) Where can I buy barium platina cyanide, and what is its cost? (*d*) Could one who has had no experience make a fluorescent screen?

W. D., Des Moines, Iowa.

ANS.—(*a*) Yes; many people have been more or less seriously injured by being improperly exposed to the influence of X-rays. The injury takes the form of a burn which is very slow in healing. Its physiological cause is not thoroughly understood. (*b*) X-rays from static machines are not considered to be as likely to burn as those from an induction coil, but this is probably due to the fact that the rays are not usually so powerful. (*c*) Barium platina cyanide is worth about 85 cents a gram, and can be purchased from The Henry Heil Chemical Co., St. Louis, Mo. (*d*) It would depend upon the person, but with proper directions no great amount of trouble should be experienced.

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(37) Your published answers to question No. 556, in HOME STUDY MAGAZINE, January, 1899, are not correct. The numbers should be, for the first condition, 128; for the second condition, 180. Similarly, the published answer to question No. 127, in the May, 1897, number, is wrong. Again, in answer to question No. 176, in the May, 1898, number, you credit Mr. Winford Lewis with a correct solution of a problem previously incorrectly answered in HOME STUDY MAGAZINE, whereas the true answer to that question is 2,151 balls.

A. M. S., Utica, N. Y.

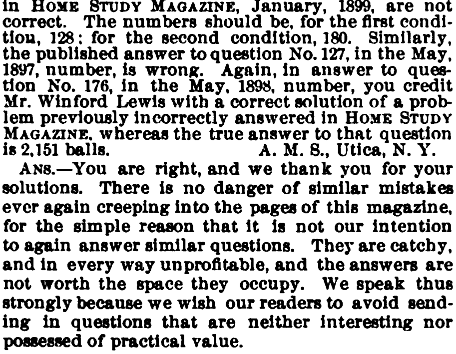
ANS.—You are right, and we thank you for your solutions. There is no danger of similar mistakes ever again creeping into the pages of this magazine, for the simple reason that it is not our intention to again answer similar questions. They are catchy, and in every way unprofitable, and the answers are not worth the space they occupy. We speak thus strongly because we wish our readers to avoid sending in questions that are neither interesting nor possessed of practical value.

***

(38) I wish to make an apparatus for distilling alcohol, but do not know how to go about it. Can you help me out?

C. J. M., Rochester, N. Y.

ANS.—For the distillation of alcohol on a small scale the apparatus shown in the accompanying figure may be used. The alcohol is boiled in a flask *A*, having a side tube *B*, which is connected to a condenser *C D*, through which cold water is passing from



D to *C*. This cools the alcohol vapors so that they are condensed to a liquid, which is received in a suitable vessel *G*. The flask *A* should be fitted with a thermometer *F* reaching a short distance below the side tube *B*, in the neck of the flask. As alcohol boils at about 79° C., the temperature indicated by the thermometer should not vary much from this during distillation. The distillation of alcohol on a large scale is discussed quite thoroughly in Sadtler's "Industrial Organic Chemistry," which may be obtained from The Technical Supply Co., Scranton, Pa.

(39) By what process are the steel balls made that are so much used now for ball bearings?

J. E., Quincy, Ill.

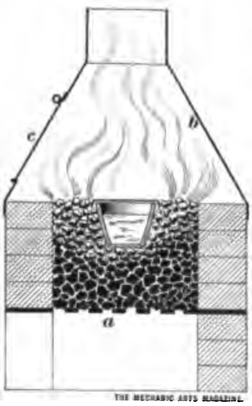
ANS.—There are two methods of producing steel balls. In one, the balls are turned by means of forming tools, in automatic machines, to nearly the finished size. In the other, they are rolled from a cylindrical piece of steel between two flat plates provided with V grooves. In both methods, the balls are hardened and then ground to the finished size between flat plates. They are now ready for final inspection. This consists of measurement with a micrometer, and an ocular inspection for flat spots.

***

(40) Can brass be melted on a small scale with an ordinary gas flame? If so, kindly explain and illustrate the necessary apparatus; something simple, that can be made at home.

A. M. D., Cincinnati, Ohio.

ANS.—Brass cannot be melted at all with an ordinary gas flame. The ordinary Bunsen flame that burns common city gas mixed with air will not melt brass. If you must melt the brass with gas, it will be necessary to use a blowpipe or forced-blast arrangement, so that a hot enough flame may be secured. We would advise you, however, to get a few good bricks and build a fireplace, something like that shown in the accompanying sketch. Build in a few iron bars at *a* to form a grate. Make a sheet-iron hood *b* to rest on top of the brick-work, and thus enclose the fire. Place a door at *c* for access to the fire.



Build this apparatus down in your cellar, and connect the hood to the best chimney flue in the house; carefully close up all openings into this flue. Kindle a fire, and use best quality bituminous coal for fuel. Sink a crucible into the heart of the fire; put in the brass or the ingredients; lay a cover over the crucible; shut the door *c*; and "let her blow." With this arrangement you will easily get enough heat to melt brass on a small scale, and the cost of the furnace will be trifling.

***

(41) (*a*) The street railway company here has been joining together the ends of the rails by pouring around them molten iron in a mold; does this process produce a true weld or only a close joint? (*b*) Could a satisfactory archer's bow be made of good spring steel? (*c*) Does a draft spring—used to connect a horse to a load—help the horse in any way?

G. M., San Francisco, Cal.

ANS.—(*a*) It produces the same kind of joint as when two lengths of lead pipe are connected by wiping lead around the ends. With the iron there may be a certain amount of surface fusing, if the metal is hot enough, but such a connection would not stand any severe vibrations, shocks, or rough usage. Electrical welding has been used for the purpose, and makes a much neater job, is more expeditious, and also more reliable. (*b*) We think it could. (*c*) The draft spring prevents too sudden strain coming on the horse when he goes at his load with a jerk. For this very reason, however, it reduces the load he can start. You must yourself have noticed that when a driver of a team of heavy horses wishes to start a very heavy load, he lets the horses plunge at their work; this is hard on the horses, but it starts the load where a steady pull would fail. Spring connection between horse and wagon makes the plunging start slightly less effective, but is easier on the horses, and also on the traces and wagon.

***

(42) (*a*) In HOME STUDY MAGAZINE, June, 1898, Answers to Inquires, No. 228, you give it as a good rule that the inlet port of a gas engine should be 12 per cent. and the exhaust-port end 16 per cent. of the piston area. Will these proportions be right for an engine that is to make 550 revolutions per minute? (*b*) Will a ¾-inch standard pipe be large enough for an inlet-port Day-type engine to run at 550 revolutions per minute, in which the gas and air mixed are admitted under about 10 pounds pressure? The size of the engine cylinder is 3 in. × 3 in. (*c*) What size exhaust port shall I need in the above engine?

S. G. M., Denver, Col.

ANS.—(*a*) Yes. (*b*) No; use a 1-inch pipe. (*c*) 1¼ square inches.

***

(43) (*a*) I am constructing a kitchen cabinet, and wish to finish it with an oil cherry stain and then to varnish it. What materials must I use, how must they be prepared, and how applied to obtain the best results? How should the surface of the wood be treated before the application of the stain? (*b*) Give me the name of a good book on the above kind of work.

A. W. B., Navarro, Cal.

ANS.—(*a*) For close-grained wood, where it is intended to finish the material in its natural color, it is well to give the work a coat of transparent liquid filler; then rub down with fine sandpaper, and apply 3 coats of a good body varnish. Each coat should be rubbed down with haircloth or curled hair, in preference to sandpaper, so that the surface will not be scratched. Where a lustrous finish is required, it is only necessary to smoothly flow on the varnish. At least two days should elapse between each coat of varnish. When open-grained material is used, it is well to apply a paste filler put on with a brush, allowing it to remain until it becomes "tacky," like dough, then rub off clean with excelsior or burlap, taking care to clean out all the corners. The surface should be allowed to harden for 24 hours before laying on the varnish. The varnish should be applied as before, rubbing the first coat with sandpaper, and subsequent ones with haircloth. If a dead, or dull, finish is desired, the last coat should be rubbed down with water and pumice stone, or oil and pumice stone. The former is preferable where first-class work is required, as a finer and softer finish is secured. It is found that equal parts of rotten stone and pumice stone will give better results than are obtained by using pumice stone alone. For cabinet work, a second rubbing should be done with rotten stone and water alone. In staining delicate woods, such as mahogany, prima vera, satinwood, maple, etc., water stain should be used, so that a clean, bright transparency will be secured, as oil stains are apt to present a cloudy or smoky appearance. In close-grained wood, the stain, whether in oil or water, is applied directly to the bare wood. *For an oil stain* the work should stand for 24 hours before being rubbed down, when the work should receive a coat of good shellac, which should be allowed an hour or two to harden, then rubbed with fine sandpaper, and treated as before mentioned. Where it is desired to stain open-grained wood, it is better to color the paste filler, to secure the desired tint, in preference to any application of stain to the bare wood. For water stain, the work should stand until the surface is thoroughly dry, after which a coat of transparent filler should be applied, and the subsequent coats laid on as already

stated. The entire work should be carefully scrutinized, and all corners, beads, and grooves cleaned out, so that sharp, well defined lines will characterize the work, as any particles of pumice stone or rotten stone, if allowed to remain, by becoming white will make the work look specky and pin-marked. (*b*) "The Painter's Encyclopædia," 427 pages, 158 illustrations, $2.00; "Everybody's Paint Book," 183 pages, 38 illustrations, $1.00; either can be had from The Technical Supply Co., Scranton, Pa.

***

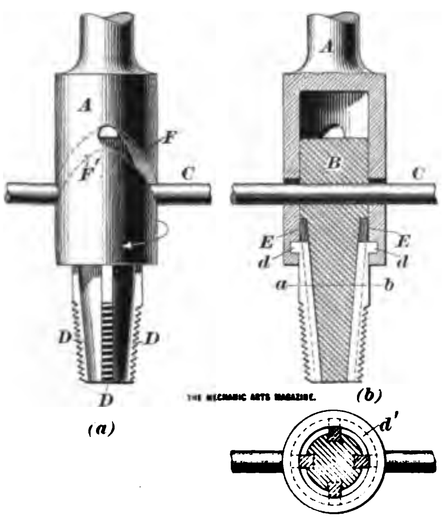
(44) I would like to be informed of the customary charges made by chemists for making analyses of coal, coke, ores, water, etc., and also for fire assays. Can you give me this information, or tell me from whom I can get it? L. A. O. G., Brookwood.

ANS.—The charges for analyses vary somewhat, in different parts of the country, with the reputation of the chemist, and also with the number of analyses made. Prices may be obtained by writing to any of the prominent analytical chemists, among whom we may mention: Ricketts & Banks, New York, N. Y.; Booth, Garrett & Blair, Philadelphia, Pa.; The Pittsburg Testing Laboratory, Pittsburg, Pa.; Dickman & Mackenzie, Chicago, Ill.; The Boston Testing Laboratories, Boston, Mass.

***

(45) What is a collapsing tap, and for what purposes is it used? Illustrate some of the designs in use, if there are any. J. F. S., New Providence, Pa.

ANS.—A collapsing tap is a tap so formed that its teeth close inward when the thread is cut, so that the cap can be withdrawn without winding it backwards. The figures show the arrangement of a simple tap of this kind; there are others of a more complicated design in the market, however. The operation is as follows: The shank *A* rotates with the spindle of the lathe or screw machine, taking



(*a*) (*b*) (*c*)

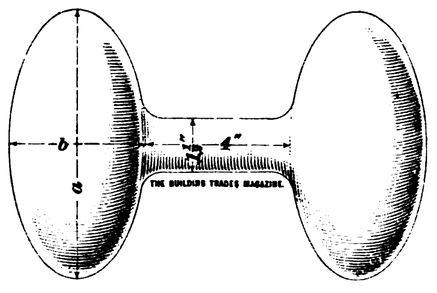
the body of the tap *B* along by means of the pin *C*. The body *B* carries the chasers *D*, which are free to slide axially in the tapering dovetail grooves *E*. These dovetail grooves are clearly shown in the view (*c*), which is a section taken on the line *ab*. The chasers have lugs *d* fitting into a circular groove of the shank *A*, shown at *d'* in the view (*c*). By turning pin *C* to follow slots *F* and *F'*, the body *B* is raised, thus drawing the chasers together. Collapsing taps are used for tapping pipe fittings or thin plates, as in the latter case turning the tap backward is apt to injure the finished thread.

***

(46) What will be the dimensions of dumbbells to weigh 10, 15, and 20 pounds each?

L. M. N., San Francisco, Cal.

ANS.—Referring to the accompanying figure, and assuming the inserted dimensions for the bar of each dumbbell, the dimensions *a* and *b* will be as follows: For a 10-pound dumbbell, $a = 4$ inches, $b = 2\frac{3}{4}$ inches;



for a 15-pound, $a = 5\frac{1}{4}$ inches, $b = 3$ inches; for a 20-pound, $a = 6\frac{3}{8}$ inches, $b = 3\frac{1}{2}$ inches. Of course, other dimensions might be chosen to give the same weight, but the above proportions are good.

***

(47) There are two questions I would like to ask regarding the design on the front cover of THE MECHANIC ARTS MAGAZINE: Who are the two characters represented, and what is the significance of the symbol in the left-hand lower corner?

A. H., Beardstown, Ill.

ANS.—The design represents the goddess of learning showing the book of knowledge to an ignorant mechanic, by the light of the lamp of knowledge. The symbol in the corner means, "Kenyon Cox, Inventor and Delineator." If you examine the symbol carefully, you will discover in it every letter in this celebrated artist's name.

***

(48) I have two 80-horsepower horizontal return-tubular boilers. The existing smokestack is too small; does not give draft enough. Can you tell me of a simple blower that will help me out of this difficulty? If there is nothing suitable on the market, can you tell me how to rig one up?

R. W. D., Montreal, Que.

ANS.—Perhaps the best and, in the long run, the cheapest thing to do would be to add to the height of your stack; or, if its sectional area is too small, put up a new stack. You could use a steam jet or blower either in the stack or in the ash-pit; but that would use up a great deal of steam, to be effective, and would be expensive. A fan blower would be more economical. The Sturtevant Company, Boston, Mass., make a special feature of this kind of work. Write them, and they will advise you for the best.

***

(49) Will you kindly tell me how to drill a hole through a piece of glass?

N. B. V., Cleveland, Ohio.

ANS.—Take a brass tube somewhat smaller than the diameter of the hole desired, and about 4 inches long; drill or file a hole in the side of this tube about 1¼ inches from one end; hold the tube in your drill press so that the hole just made is out of the chuck about ¼ inch. Lay a piece of felt, or other soft substance, upon the drill table, and your glass upon that. To thus back the glass, you may, if you prefer, use a piece of soft wood about three times the diameter of the hole, and lay your glass upon that; do

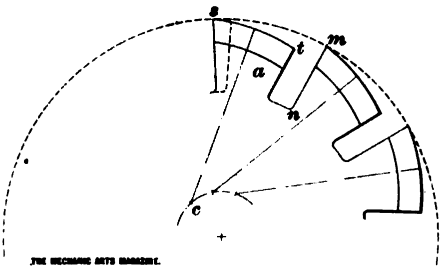
not, however, use too large a piece of wood, or its unevenness, or that of the glass, may cause the latter to crack. By means of your drill spindle, bring the tube down upon the glass lightly, and hold it there; then fill the tube with fine emery and water through the hole near the chuck, and start your drill at a rather high speed; feed very gently, or you will break the glass. The emery in the tube should be kept very wet all the time. The hole in the glass, thus drilled, will be somewhat larger than the outside diameter of the drilling tube, because some emery will work through to the outside of the cutting end of the tube; if the tube does not run true, the hole drilled will be larger still.

***

(50) The Brown & Sharpe Mfg. Co. make milling cutters of various forms which can be sharpened, by grinding the tooth faces, without changing the form of the cutting edge. How are the teeth "backed off" so that the shape of the cutting edges is preserved? Is it done by special machinery, and how could it be done economically in an ordinary machine shop?

J. H. McC., New Haven, Conn.

ANS.—The accompanying illustration will enable you to understand the principle upon which these cutters are made. Each tooth is backed off on a curve that is an arc of a circle whose center is at a certain



distance from the center of the cutter itself; for example, c is the center of the back-off curve of tooth a. The backing-off machines used by the Brown & Sharpe Mfg. Co. were made especially for the purpose, and this form of cutter itself was patented by them. After the teeth have been formed, with the exception of the backing off, the cutter is operated on in this special tool, in which it is rotated slowly, while for every tooth the cutter is feed *in*, thus producing the curved surface as at $s\,t$. At the moment that the back end t passes the tool, the latter is caused to fly out to its original position, and the backing off of the next tooth commences. To sharpen, each tooth is ground on the face $m\,n$ and is good until too weak for its work. We hardly think it would pay you to attempt to do this work with ordinary machine-shop facilities; better write to the manufacturers.

***

(51) What, in your opinion, are the best books on strength of materials, applied mechanics, and machine design, for one who has completed these subjects in The International Correspondence Schools, and wishes to continue his studies?

R. A. O., Boston, Mass.

ANS.—The following list of books is suggested as most nearly meeting your requirements: "The Strength of Materials," by Merriman, $1.00—quite elementary, and not mathematical. "Mechanics of Materials," by Merriman, $4.00—a complete and mathematical treatise. "The Mechanics of Machinery," by A. B. W. Kennedy, $3.50—this book is particularly recommended. "Advanced Textbook on Applied Mechanics," Jamieson, $2.50. "Elementary Mechanism," by Stahl and Woods, $2.00. "Elements of Machine Design," W. C. Unwin, Vol. I. $2.00; Vol. II, $1.50. "A Manual of Machine Drawing and Design," Low and Bevis, $2.50. These books may be obtained from The Technical Supply Co., Scranton, Pa.

***

(52) I have today sent you a sample of sediment taken from a 10-horsepower upright steam boiler. Can you tell me what the sediment is? In order that you may be able to give me advice as to how to prevent its formation, I will give you the facts as I know them: The boiler furnishes steam to a 3-horsepower engine; it is fed from a supply tank into which the water is pumped from the river; all pipes are iron; the feed-barrel is perfectly clean, and so is the tank; the soil through which the river flows is of volcanic origin and contains much pumice stone; I enclose a sample of the rock of which the surrounding mountains are composed. The sediment is all over the inside of the boiler, and feels like sharp sand; it dissolves in water when rubbed between the fingers. I may add that I do not see any possible way in which oil could get into the boiler.

M. A. C., Sitka, Alaska.

ANS.—The "sediment" you enclose is oxide of iron—in other words, rust gathered off the plates. The very small particles may have appeared to you to dissolve when treated as you say; in reality, however, they were merely worked off into the body of the surrounding water, and, the particles being fine and widely disseminated, this misled you. So long as any sediment (when it is such) merely settles on the plates and in no way *cakes* there, there is not much cause for alarm, for such material can easily be washed out of the boiler. The danger arises when a thick hard scale forms on the plates. Of course, there may be a trace of acid in the water you use, which may have attacked the plates a little; you can keep an eye on the latter, and note any early symptoms of corrosion. If you have reason to think there is any acid present, caustic soda or slaked lime will neutralize it. You do not say whether you use your exhaust steam at all to heat your feed. If you do use it, the oil that goes over with the exhaust may, if animal or vegetable, form acids in the boiler.

***

(53) In a recent issue of HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., I see it stated that the air chamber of a force pump should have a capacity three times that of the piston displacement; also, that the neck of the air chamber should be smaller than the other part. Will you kindly tell me why the neck should be smaller? I know that air chambers on ordinary pumps in domestic use are not nearly three times the capacity of the cylinder. I would like to have this matter further explained. Again, why should the air chamber be nearest the spout, or delivery opening? I am interested in the construction of hand force pumps, and these things puzzle me. Can you recommend any book on the subject?

H. W., Stratford, Pa.

ANS.—The capacity of the air chamber to which you refer is suitable for power pumps working with moderate piston speeds and against moderate pressures. Hand pumps for domestic purposes may be used with smaller air chambers, or even with none; a suitable air chamber, however, makes the pump work more easily and steadily; it also reduces the wear on the packing and valves and the danger of bursting the pipes. With a smaller neck, the air chamber is more efficient in equalizing the flow of the water and regulating the action of the pump; there is, however, a limit, below which the size of the neck should not go; an air chamber with a neck having the same internal diameter as the discharge pipe will give good results. We did not mean to infer that the air chamber should be at the delivery end of the discharge pipe, but that it should be placed on the pump near the point at which the discharge pipe is attached. In the case of a hand pump forcing

water from a well into a bucket at the surface, there would be no use in attaching an air chamber to the spout; if, however, a hose or a long pipe were attached to the spout for the purpose of forcing water to a considerable distance from the pump, an air chamber on the spout would be very beneficial. We do not know of any book on the subject of small hand-power pumps. "Pumping Machinery," by William M. Barr, a very complete treatise on the subject of power pumps of all kinds, may be obtained from The Technical Supply Co., Scranton, Pa.; price, postage prepaid, $5.00.

***

(54) (*a*) In gas engines what style of igniter gives the best results? Can you give me descriptions of the various kinds in use? (*b*) Where can I get information regarding gasoline motocycles suitable for carrying two persons? R. F. G., St. Paul, Minn.

ANS.—Both hot-tube and electric igniters give good results. The trend of modern practice seems to be in favor of the electric igniter, especially for gasoline engines. SEE HOME STUDY MAGAZINE, March, 1898, article entitled "The Gas Engine." (*b*) Write to the "Horseless Age," 216 William St., New York, N. Y.

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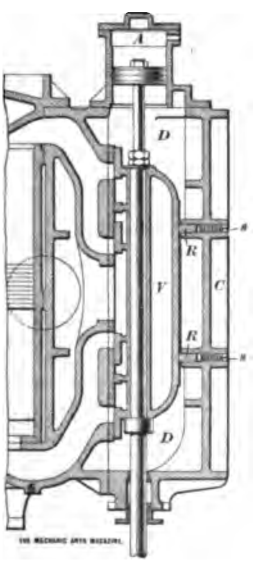
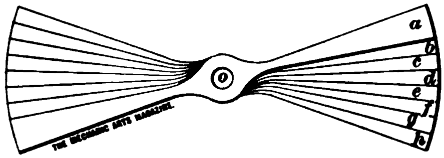
(55) (*a*) Why are cams used in place of eccentrics to run the valve gear on steamboats? (*b*) What is the principle of the balanced valve, and how is the valve constructed? (*c*) What is a spring relief valve? J. M. S., Reverie, Tenn.

ANS.—(*a*) Cams are used because they give quick opening and closing of the steam and exhaust ports. (*b*) Any valve constructed in such a manner that the steam pressure will not force it against the valve seat is said to be *balanced*. There are numerous constructions. Perhaps the most common construction of a balanced slide valve, as used in marine work, is that shown in the figure. The back of the valve *V* is planed; bearing against this is a circular ring *R* closely fitted into an annular groove in the steam-chest cover *C*; this ring is made to bear steam-tight against the back of the valve by flat springs, which can be set out by the setscrews *s*. In operation, the steam fills the steam chest *D D* and presses only against that part of the valve not covered by the ring *R*. In the design shown, the weight of the valve is balanced by means of the balance cylinder *A*; the lower side of the closely fitted piston in the latter is exposed to the steam pressure; the space above the piston communicates with the condenser. The balance cylinder is so proportioned that the force tending to push the piston upwards is equal to the weight of the valve. (*c*) A spring relief valve is similar in construction to a spring-loaded safety valve; it is fitted to a cylinder to afford relief in case water gets into the latter.



(56) Please give a description of the construction of steamship screw propellers. B. E. H., Wilmington, Del.

ANS.—There are several methods of building up the pattern of a screw propeller, one of which is shown in the figure. For a two-bladed propeller, cut a number of pine boards similar to that shown at *a*, with a hole *o* in the center of each. Then make a mandrel which fits to the hole, and fasten it firmly to the bench. Slip the pieces over the mandrel, and spread after the fashion of a fan, as shown in the figure. The pattern may now be cut to its proper shape by following the edges of the pieces *a*, *b*, *c*, *d*, *e*, *f*, *g*. The proper shapes of these pieces must be



determined beforehand by the designer of the screw. Another method is to build the pieces up roughly, taking care that they shall be large enough for the finished blade. In this method the hub is made separately, only one pattern being constructed for all the blades. An arm is made to swing around the mandrel, the opposite end following a curved form, so that, in moving up or down the mandrel, the arm must pass along a surface just like the face of the finished screw. The pattern is then cut down until all points on its surface are at the same distance from the arm. A third method, and one much used for large screws, is to "sweep them up" in the foundry with an arm, arranged as described, for the pattern.

***

(57) I am building gasoline engines, and am having trouble with the igniter point burning off. I have tried platinum and hard- and soft-steel points without success. They last about a week. What, in your opinion, is the best material to use for igniter points, and how should the points be proportioned? In my engine the spark is made by quickly separating the contact points; I use 6 Edison-Lalande large sized cells and a ten-inch spark coil. J. W. W., Galena, Ill.

ANS.—It is a difficult matter to point out a remedy without knowing more of your igniter. There are several ways in which this trouble may be overcome, but each one is applicable to a particular form of igniter and may prove useless for another. Consult an expert on the spot.

***

(58) I wish to build a twenty-five 16-candlepower dynamo similar to the one illustrated in HOME STUDY MAGAZINE, May, 1898, Answers to Inquiries, No. 173. What should be the dimensions of the field core, and what size and amount of wire should I use? Also, what should be the dimensions of the armature, how many segments should there be in the commutator, what size and amount of wire will the armature require, and what should be the diameter of the armature shaft? J. A. N., Galesburg, Ill.

ANS.—We presume you refer to Answers to Inquiries, No. 159, where a chord winding is illustrated. You can make a bipolar dynamo of 2½ horsepower of about the following dimensions: armature core, 8 inches in diameter, 4 inches long; 24 slots, 28 turns per slot, No. 12 wire; commutator, 12 segments; field core, 3½ inches in diameter; field spools wound with No. 22 wire; shaft in bearings, 1¼ inches in diameter; speed, 1,000 to 1,200 revolutions per minute. This will give about 115 volts, but a good deal will depend upon the quality of iron which you use. Make the air gap about ⅛ inch each side.

(59) Is the principle of enclosing the crank chamber of a gas engine and using it as a part of the two-cycle method of construction patented? If so, what is the number and date of the patent?

E. R. P., Montpelier, Vt.

ANS.—We do not think there is a United States patent on this feature of the gas engine. If you wish to find out positively, employ a patent attorney.

***

(60) What is the best book you know of on sheet-metal-work layouts? E. Q., Chicago, Ill.

ANS.—"The New Metal Workers' Pattern Book," by Geo. W. Kittredge; price $5.00; for sale by The Technical Supply Co., Scranton, Pa.

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(61) I have been having an argument with a building committee here as to the best way of placing joists and studding on the sill of a balloon frame.

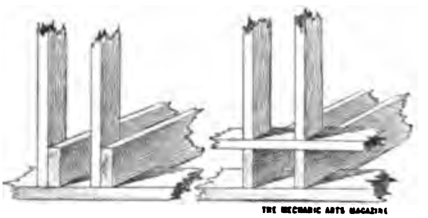


FIG. 1. FIG. 2.

I claim that the arrangement shown in Fig. 1 is the better; they claim that the arrangement shown in Fig. 2 is just as good. Kindly settle the dispute by stating which construction is the better and more durable, and explain why. Allow for both being sheathed on the outside at an angle of 45°.

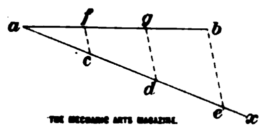
L. B. W., St. Johns, Pa.

ANS.—Fig. 1 is always preferable. The shrinkage of the joists, which is inevitable in framing timbers, would cause the wall studs to settle, or, if they remained in position by being supported by the diagonal sheathing, they would be liable to sway during a heavy wind storm.

***

(62) Kindly describe how a line can be trisected geometrically. A. B. C., Holyoke, Mass.

ANS.—Let it be required to trisect the line ab. Through the point a draw a line ax making any angle with the line ab. On ax take any length ac, and make cd and de each equal to ac. Join e to b, and draw the lines cf and dg parallel to eb. Then the line ab is trisected at the points f and g. In order to obtain good clear intersections, bax should be an acute angle, and ac should be made approximately equal to one-third of ab.



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(63) (a) In HOME STUDY MAGAZINE, January, 1899, I notice an article entitled "The Gasoline Engine." What is the name of the vertical engine illustrated there, and who makes or sells it? (b) The same article speaks of a two-cylinder engine that gives two impulses every revolution of the crank-shaft. I have an engine with two cylinders (a Hicks gasoline engine) that gives one impulse to each revolution, and I do not see how it could give two impulses. Please explain. (c) An army 50 miles long marches 50 miles in 10 hours. At the time the army starts, the commanding officer starts from the rear on horseback, rides to the front and returns, reaching the rear of the army again at the precise moment that the army completes the ten hours' march; how far does the officer travel, assuming his rate of motion to be uniform? Can this question be solved without the use of algebra? If so, show figuring.

C. C. G., Attleboro, Mass.

ANS.—(a) The Sintz Gas Engine Co., Grand Rapids, Mich., are the makers of the Sintz engine, of which the illustration you refer to is a sectional diagram. (b) Two-cycle engines give an impulse at each revolution of the crank-shaft. Two such engines coupled to the same shaft, with impulses alternating, give one impulse each per revolution, or two impulses per revolution. (c) Let AD be a straight line 100 miles long, and B its middle point. At starting, let the rear of the army be at A, and its front at B; at the end of the march the head will be at D, and the rear at B. Let C be the point where the officer turns. The rates of marching of the army and the officers, being uniform, will be proportional to the distances traveled by them in the same time. Therefore,

$$\frac{\text{army's rate}}{\text{officer's rate}} = \frac{BC}{AC} = \frac{CD}{BC};$$

or,

$$\frac{\text{army's rate}}{\text{officer's rate}} = \frac{x}{50+x} = \frac{50+x}{x}.$$

Whence,

$$x^2 = (50+x)(50-x) = 50^2 - x^2,$$

which gives $x = 25\sqrt{2}$. The whole distance traveled by the officer is

$$AB + BC = 50 + 2 \times 25\sqrt{2} = 50(1+\sqrt{2}).$$

This question cannot be solved without the use of algebra.

***

(64) What is the horsepower of a gasoline engine of the following dimensions: cylinder, 4 inches in diameter; stroke, 5 inches; revolutions per minute, 600; an explosion every revolution. Please show the figuring. T. H. T., El Paso, Texas.

ANS.—The following formula will give the average brake horsepower of a two-cycle engine:

$$H = \frac{D^2 \times L \times R}{14{,}000},$$

where D = diameter of cylinder, in inches;
L = stroke of piston, in inches;
R = number of revolutions per minute;
H = the average brake horsepower.

Substituting in the above formula the values given, we have

$$H = \frac{16 \times 5 \times 600}{14{,}000} = 3.43 \text{ horsepower.}$$

The average horsepower is about two-thirds of what the engine will give under the very best conditions.

***

(65) (a) In what way does a magnet break an arc in controllers and other car equipment, and (b) what is a condenser for an induction coil?

A. E. R., Harrisburg, Pa.

ANS.—(a) The action of the lines of force from a magnet upon a current in the form of an arc is the same as the action upon a wire carrying a current. When the direction of the arc is at right angles to the lines of force due to the magnet, the arc is repelled and its path is lengthened until it is broken. (b) The condenser is used to neutralize the self-induction of the windings, thereby producing an increased length of spark between the terminals of the secondary coil.

***

(66) (a) What is the rule for calculating the proper size of brake for a locomotive? (b) How is the logarithm of a number found, without the use of a table? J. R. B., Fredericksburg, Va.

ANS.—(a) Use a braking force equal to 75 per cent. of the weight on the wheels that are to be braked. (b) You will find the information you require in an article entitled "Napier" published in two parts in HOME STUDY MAGAZINE, December, 1897, and January, 1898. It is a waste of time attempting to make use of logarithms unless you have a table.

(67) I wish to construct a "magnetic separator" for separating iron filings and turnings from brass. Kindly answer the following questions in regard to the separator: (*a*) How can I fasten the magnets to the copper cylinder? (*b*) We have a small dynamo which is used for plating; could it be used to magnetize the cylinder without injuring the dynamo or affecting the current for plating? (*c*) Could the copper cylinder be magnetized by any other means than by a magnet? (*d*) From whom can such a machine be purchased?

W. B. M., Baltimore, Md.

ANS.—(*a* and *c*) It is not possible to magnetize a copper cylinder. The principle of a magnetic separator is shown in the figures. Fig. 1 is an end view, with half of the cylinder *d* cut away to show the magnets. Fig. 2 is a cross-section of Fig. 1 on the line *a b*. The magnet cores *m* are cast in one piece with the support *S*, and, after th ecoils *k* are put on, the pole pieces *p* are fastened in place by means of machine screws as shown. The drum *d* is made of copper or brass, and has a flange *f* on each side. The drum is made to revolve by means of crank *c*, and the filings are allowed to fall upon it from the hopper *h*. The brass, not being attracted by the magnets, falls into the box *B*, while the iron turnings are carried past the partition and fall into *I*. (*b*) Yes, if the resistance of the coils is not too low. (*d*) We do not know of a firm that makes as small

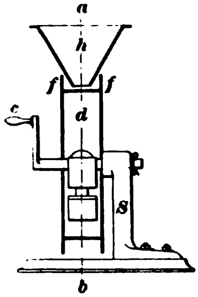


FIG. 1.

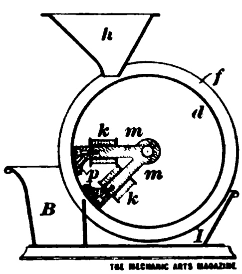


FIG. 2.

a machine as you would probably require, but we suggest that you write to Thomas A. Edison, Orange, N. J.; he has experimented with magnetic-ore separators, and will no doubt be glad to help you.

***

(68) (*a*) How much power could be obtained from a pipe line 48 inches in diameter, and falling 400 feet in 20 miles? (*b*) How much, falling 900 feet in 40 miles? The water would be taken from a rapidly running mountain stream where the conditions are not favorable to fluming—at any rate, not at many points.

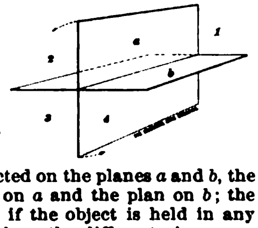
FLUME, New York, N. Y.

ANS.—(*a*) The maximum power that can be obtained depends on the condition of the pipe. If it is smooth and well laid, without sudden bends or changes of level in which air can collect, the maximum theoretical power represented by the energy of the water as it leaves the pipe might be as much as 1,800 horsepower. With a cast-iron pipe in ordinary condition, the maximum theoretical energy that could be obtained might not be more than 800 horsepower. (*b*) From 2,500 to 4,000 theoretical horsepower, depending on the condition of the pipe. The actual power that could be developed depends on the efficiency of the motor used; under favorable conditions, an efficiency of 75 per cent. should be obtained. In order to obtain the maximum power from long pipes under the above conditions, the flow should be so regulated that the pressure head at the discharge end of the pipe is about ⅓ of the total fall.

(69) What do the expressions *first angle* and *third angle* mean, as applied to different methods of projection in mechanical drawing?

MECHANIC, Jersey City, N. J.

ANS.—Let a vertical plane *a* intersect a horizontal plane *b*, as shown in the figure. Then there will be formed 4 dihedral angles, as indicated by the numerals *1*, *2*, *3*, *4*.



The angle above *b* and in front of *a* is called the *first angle*, and the angle directly opposite, that is, the angle below *b* and behind *a*, is called the *third angle*. If an object is held in the first angle and is projected on the planes *a* and *b*, the elevation will appear on *a* and the plan on *b*; the same is of course true if the object is held in any other angle. Now, to show the different views on a plane surface like a sheet of paper, the plane *a* is conceived to be revolved, in the sense shown by the arrows, until it coincides with the plane *b*. It is readily seen that, if the object is in the first angle, this revolution brings the elevation above the plan; while, if the object is in the third angle, the plan will be above the elevation.

***

(70) Is there any book on electricity that shows how, by means of simple arithmetic, the sizes and amount of wire, the amount of iron, and other matters incidental to the designing of dynamos and motors can be figured? J. J. C., Dubuque, Ind.

ANS.—A simple exposition of the principles of dynamo design is given in the "American Electrician," August, 1898, and succeeding issues up to date. The subject is carefully considered under the head of "Lessons in Practical Electricity." You cannot do better than subscribe to that publication.

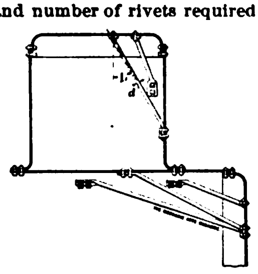
***

(71) (*a*) What should be the maximum thickness between bars of commutators for motors of from 20 to 35 horsepower? (*b*) What would be the result if this thickness were exceeded? A. A. A., Johnstown, Pa.

ANS.—(*a*) About .035 inch. (*b*) The effect of a greater thickness would be a reduction of the collecting surface for current.

***

(72) (*a*) Give size and number of rivets required in the reinforcement ring, made of ½-inch plate, for a 15″ × 11″ manhole. (*b*) I enclose a sketch of the diagonal stays in a marine boiler. Kindly show how the stress on each stay is determined. E. P., Sault St. Marie, Mich.



ANS.—(*a*) The ring should be 4 inches wide to keep rivets well from the edge of the hole; diameter of rivets, ¾ inch to ⅞ inch the distance between centers is from 3 to 3¼ inches. (*b*) Let A = area, in square inches, of plate supported by the diagonal stays;

d = smallest diameter of stay, in inches;
n = number of stays;
L = angle of stay;
p = steam pressure in pounds per square inch;
S = safe stress in pounds per square inch (= 6,000 pounds by law).

Then,

$$d = 1.128\sqrt{\frac{A}{n} \times \frac{p}{S \cos L}}.$$

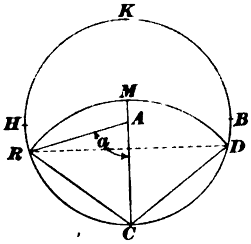
(73) Please explain in detail the electric signals as used on railroads. How does the engineer receive the signals? A. W. B., Miles Grove, Pa.

ANS.—In another part of this number there is an article entitled "Railroad Block Signaling," which we believe contains the information you are after; your inquiry is rather indefinite, however, as electricity is used in many ways on railroads.

***

(74) In the accompanying diagram the circle $BCHK$ is described with a given radius AB. The arc RMD is described with a radius CD, which is of such a length that the area contained by it and the arc DCR of the first circle is equal to one-half the area of the first circle. What is the length of the radius CD?

A. M., Port Morien.



THE MECHANIC ARTS MAGAZINE

ANS.—Let R denote the radius of the given circle, x the radius of the circle whose center is C, and a the circular measure of the angle RAC. Then we have

$$\text{Area of segment } RCD = R^2(a - \tfrac{1}{2}\sin 2a). \quad (1)$$

$$x = 2R \sin\frac{a}{2}. \quad (2)$$

$$\text{Angle } RCA = \tfrac{1}{2}(\pi - a). \quad (3)$$

$$\text{Area of segment } RMD = \frac{x^2}{2}(\pi - a - \sin a). \quad (4)$$

Therefore, area of segment

$$RMD = 2R^2 \sin^2\frac{a}{2}(\pi - a - \sin a). \quad (5)$$

Combining (1) and (5) we get
Area of lune $RCDM$ =

$$R^2\left[a - \tfrac{1}{2}\sin 2a + 2\sin^2\frac{a}{2}(\pi - a - \sin a)\right]. \quad (6)$$

In formula (6) put

$$\tfrac{1}{2}\sin 2a = \sin a \cos a,$$

and

$$2\sin^2\frac{a}{2} = 1 - \cos a.$$

Then we get
Area of lune $RCDM$ =

$$R^2[\pi - \sin a - (\pi - a)\cos a]. \quad (7)$$

Formula (7) gives the simplest expression for the area of the lune $RCDM$. By the conditions of the question, this must be equal to one-half of the area of the given circle; hence,

$$R^2[\pi - \sin a - (\pi - a)\cos a] = \tfrac{1}{2}\pi R^2;$$

whence,

$$\sin a + (\pi - a)\cos a = \tfrac{1}{2}\pi. \quad (8)$$

The angle a must be found from equation (8), and then the required radius x is found from equation (2). Equation (8) can be solved by trial only, and gives

$$a = 1.2358967.$$

Therefore, the angle $RAC = 70° \, 48' \, 42''$.

Hence, $x = CD = 2R\sin\frac{a}{2} = R \times 1.158718.$

***

(75) About what size boat could be run at a speed of from 8 to 10 miles an hour with a 2½-horsepower gasoline engine? The weight of the engine complete is 240 pounds; its height is 25 inches. What size of screw propeller would you recommend?
H. A. W., Beloit, Wis.

ANS.—Your engine is suitable for a boat of ordinary proportions, about 21 feet long, but it will not be practicable for you to get more than 7 miles an hour from such a boat. For greater speeds you would require a special design of hull, and even then the result would be a very cranky craft. A 20-inch propeller, with either two or three blades, will be about right.

(76) (*a*) Is there any way that a gas engine can exhaust under water without throwing the back pressure into the cylinder? (*b*) Do you know of any device that will stop the noise of the exhaust from a gas engine, without throwing the back pressure into the cylinder? J. W., Utica, N. Y.

ANS.—(*a*) None, that we are aware of. (*b*) See HOME STUDY MAGAZINE, March, 1898, article entitled "The Gas Engine," Fig. 7.

***

(77) (*a*) Why is the number of coils short-circuited, greater at maximum load and less at minimum load, in a Wood arc dynamo? (*b*) How is sparkless commutation secured? A. B., Joliet, Ill.

ANS.—(*a*) The coils short-circuited are in the neutral space, so that they are not being utilized for generation of E. M. F. They are cut out at maximum load in order to reduce the back ampere-turns of the armature, and to cut down the resistance in the circuit. When the load is small, the back ampere-turns are needed to weaken the field. (*b*) The current output is so small that the sparking is slight.

***

(78) (*a*) Please explain what single-phase, two-phase, three-phase, and monocyclic systems are, in what they differ from each other, and which is the best system. (*b*) What is an inductor, as applied to a generator of electricity? H. G., Somerset, Man.

ANS.—(*a*) Your question is entirely too comprehensive for these columns. You will find the subject explained in Houston and Kennelly's "Alternating Electric Currents," which may be procured from The Technical Supply Co., Scranton, Pa., price $1.00. (*b*) The inductor type of generator is one in which no moving wire is used, the variations in flux density through the armature coils being obtained by moving past them masses of laminated iron.

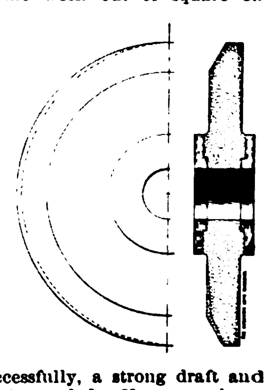
***

(79) A few days ago I was asked and was unable to solve the following problem: Given a circle 20 inches in diameter; with a point on its circumference as center, what is the radius of the arc that will divide the area of the circle into two equal parts? Will you kindly show and explain the solution? D. McK., Milton, C. B.

ANS.—See Answers to Inquiries, No. 74. Putting $R = 10$ inches in the answer to that question, we get the required radius to be 11.58718 inches.

***

(80) (*a*) How should I proceed to true up an emery wheel that has become worn out of square on face and sides, as indicated by the dotted lines on enclosed sketch? What is the best tool for the purpose? (*b*) What changes will it be necessary to make in a steam-boiler furnace now burning soft coal, in order to burn coke? LINO.



ANS.—(*a*) There are tools specially made for truing up emery wheels. Write to Charles A. Strelinger & Co., Detroit, Mich.; they are dealers in every kind of special tool. (*b*) To burn coke successfully, a strong draft and plentiful air supply is needed. You may have to change your grate so that the spaces between the grate bars are about ½ of an inch. We would recommend that you increase your grate surface by about one-third.

SELF HELP DEPARTMENT.

THE HABIT OF STUDY.

THE man with the habit of study is invincible. No danger appals, no obstacle vanquishes, no sense of fear visits him. The value of this habit and purpose of study is well illustrated by an example from "Success."

"I remember very well," said Charles Francis Adams, "when William H. Baldwin entered the service of the Union Pacific Railroad. I was then president of the road.

"President Eliot of Harvard first called my attention to the young man, recently graduated. He said that he considered him a good man for the railroad business. We are always looking for first-class young men, you know; so I found a place for him with the Union Pacific.

"He was sent West, and soon began to distinguish himself. His energy and ability secured rapid promotion at Omaha and at Butte City. When I ceased to be president of the Union Pacific Railroad, Mr. Baldwin resigned his position too. He was then general manager, I believe, and had made himself of the greatest usefulness to the road. He had shown himself to be possessed of all the qualities that go to make up a successful railroad manager, including the rather rare one of great integrity. Upon leaving the employ of the Union Pacific, he became general manager of the Flint and Père Marquette Railroad, and became very popular as before.

"Messrs. Morgan & Co. had their eyes on him all this time, and subsequently he was employed by them. He was sent down to take charge of the Southern Railroad Company, and was again successful.

"Mr. Baldwin has simply shown, during his employment by these railroads, that he has energy, character, mental alertness, and the important faculty of minding his own business. These have made him what he is. I think highly of him. Yes, I believe him to be the most promising railroad man in the country."

This is indeed high praise, coming from one of the greatest railroad organizers of the century. But it is still further emphasized by the election, in September, 1896, of this Boston boy, but little more than thirty years of age, to succeed the late Austin Corbin as president of the Long Island Railroad.

Such a career is a good illustration of what strict application will do, when combined with a good education, intelligent appreciation of what is required, and adaptability for work.

Mr. Baldwin is the youngest railroad president in the East. He is only thirty-four years old, and has risen in about ten years from a clerkship in a Western railroad office to the presidency of one of the finest railroad properties of its kind in the United States.

He was born in Boston, February 5, 1863. His father is president of the Young Men's Christian Union, a position he has filled with great ability for nearly thirty years. Young Baldwin was graduated from the Roxbury Latin School with honors, and completed his course at Harvard in 1885.

He was very popular with all classes while at Harvard, and was president of the Harvard Glee Club, and also of the Memorial Hall Dining Association, a cooperative organization of the college students. Under "Billy Baldwin's" administration everything was conducted in an eminently satisfactory manner. Here was where he made his first "hit" in a business sense; and when, late in 1885, Charles Francis Adams said he was looking for a bright, reliable young man to place in the head office of the Union Pacific Railroad at Omaha, President Eliot instantly recommended young Baldwin for the position, to which he was promptly elected.

How true the noble saying of George Eliot: "The only failure a man ought to fear is failure in cleaving to the purpose he sees to be best."

SUCCESS THROUGH PERSEVERANCE.

IT WAS when Cyrus W. Field had retired from business with a large fortune that he became possessed with the idea that, by means of a cable laid upon the bottom of the Atlantic Ocean, telegraphic communication could be established between Europe and America. He plunged into the undertaking with all the force of his being. The preliminary work included the construction of a telegraph line, 1,000 miles long, from New York to St. John's, Newfoundland. Through 400 miles of almost unbroken forest they had to build a road as well as a telegraph line across Newfoundland. Another stretch of 140 miles across the island of Cape Breton, involved a great deal of labor, as did the laying of a cable across the St. Lawrence.

By hard work he secured aid for his company from the British government, but in the United States Congress he encountered such bitter opposition that his measure only had a majority of one in the Senate. The cable was loaded upon the Agamemnon, the flagship of the British fleet at Sebastopol, and upon the Niagara, a magnificent new frigate of the United States Navy; but when five miles of cable had been paid out it caught in the machinery and parted. On the second trial, when 200 miles at sea, the electric current was suddenly lost, and men paced the deck nervously and sadly, as if in the presence of death. Just as Mr. Field was about to give the order to cut the cable, the current returned as quickly and mysteriously as it had disappeared. The following night, when the ship was moving but 4 miles an hour and the cable running out at the rate of 6 miles, the brakes were applied too suddenly just as the steamer gave a heavy lurch, breaking the cable.

Field was not the man to give up. Seven hundred miles more of cable were ordered, and a man of great skill was set to work to devise a better machine for paying out the long line. American and British inventors united in making a machine. At length in mid-ocean the two halves of the cable were spliced, and the steamers began to separate, the one headed for Ireland, the other for Newfoundland, each running out the precious thread, which, it was hoped, would bind two continents together. Before the vessels were 3 miles apart, the cable parted. Again it was spliced, but when the ships were 80 miles apart, the current was lost. A third time the cable was spliced and about 200 miles paid out, when it parted some 20 feet from the Agamemnon, and the vessels returned to the coast of Ireland.

Directors were disheartened, the public skeptical, capitalists were shy, and but for the indomitable energy and persuasiveness of Mr. Field, who worked day and night almost without food or sleep, the whole project would have been abandoned. Finally a third attempt was made, with such success that the whole cable was laid without a break, and several messages were flashed through nearly 700 leagues of ocean, when suddenly the current ceased.

Faith now seemed dead except in the breast of Cyrus W. Field and one or two friends; yet, with such persistence did they work that they persuaded men to furnish capital for another trial, even against what seemed to be their better judgment. A new and superior cable was loaded upon the Great Eastern, which steamed slowly out to sea, paying out as she advanced. Everything worked to a charm until within 600 miles of Newfoundland, when the cable snapped and sank. After several fruitless attempts to raise it, the enterprise was abandoned for a year.

Not discouraged by all these difficulties, Mr. Field went to work with a will, organized a new company, and made a new cable far superior to anything before used, and on July 13, 1866, was begun the trial which ended with the following message sent to New York:

"Heart's Content, July 27.

"We arrived here at nine o'clock this morning. All well. Thank God! The cable is laid and is in perfect working order. Cyrus W. Field."

The old cable was picked up, spliced, and continued to Newfoundland, and the two are still working, with good prospects for usefulness for many years.

Successful men, it is said, owe more to their perseverance than to their natural powers, their friends, or the favorable circumstances around them. Genius will falter by the side of labor, great powers will yield to great industry. Talent is desirable, but perseverance is more so.

"The man who seeks one thing in life, and but one,
May hope to achieve it before life be done;
But he who seeks all things, wherever he goes,
Only reaps from the hopes which around him he sows,
A harvest of barren regrets."

THE tree of knowledge is known by its fruits. "Culture," says Oliver Wendell Holmes, "in the form of fruitless knowledge, I utterly abhor."

HIRAM S. MAXIM.

THE APPRENTICE WHO BECAME A GREAT INVENTOR.

HIRAM S. MAXIM was born on the fifth day of February, 1840, in the town of Sangerville, Me. He attended the local school until he was fourteen years of age, when he went to work for his father, a carriage builder by trade.

He did not remain with his father long, but entered his uncle's engineering works at Fitchburg, Mass., as an apprentice, where he served his time and became the foreman before he was 21.

At about the age of 25 he engaged with a philosophical instrument maker as a mechanical draftsman, and at 28 became the draftsman of a large steamship building company in New York.

In his spare moments he was a diligent student, ever striving to master the principles which underlay the subject of his employment. It is this very spirit of inquiry into the minutest details, which is the distinguishing characteristic of his work as an inventor.

When but a lad, he invented an automatic mouse trap, and soon after, a gas headlight for locomotives, which was finally abandoned owing to objections to the use of gasoline. In 1871 he patented a gas-generating apparatus for houses, and a steam trap or valve, still a standard type. Other inventions followed rapidly; among them being automatic steam pumping engines, feedwater heaters, engine governors, gas motors, and liquid meters.

But his most noted inventions are in electrical apparatus, aeronautics, and machine guns. Maxim was among the foremost of the early experimenters who perfected the arc lamp, and he was the first to invent a practical regulator for feeding the carbons.

It is not generally known that Edison did not abandon the use of the platinum conductor in incandescent lamps until Maxim had proven the superiority of carbon, and overcome the objections to its use. His patented regulator for dynamo brushes was the means of breaking the monopoly enjoyed by Thomson, Houston & Co., and in 1880 Maxim patented the first arc lamp used in New York City for open-air illumination.

In 1883 he removed to England to take up his permanent residence, believing that the patent laws of that country furnish more protection for the inventor than do those of the United States. It was in England that he perfected the machine guns which have made him famous. The difficulties encountered were enough to discourage any ordinary man, but he persevered until his gun, firing 700 shots a minute, was recognized as the most deadly weapon of warfare in existence.

He began his famous experiments in aeronautics in 1889, and on the 31st of July, 1894, his experimental machine lifted itself from the ground, with three men, by its own contained power, the first instance of the kind in the history of the world. He solved such important problems with this machine, that it is believed that in ten or fifteen years we shall probably see a practical flying machine.

The inventor lives with his wife at London, where he still continues his experiments. His success has been brought about chiefly by diligent study, keen observation, and persistence of purpose. No difficulties or orthodox principles have deterred him from assiduously and resolutely pursuing his own convictions, and, similar to a legion of great and successful men, he may be appropriately described as a "self-made man," and the designer of his own fame and fortune.

SELF-CONTROL AND SELF-DISCIPLINE.

THE value of teaching self-control—the control of the will—is often overlooked in the mere pursuit of knowledge. A recent article in a late journal by Dr. DeBlois, of Shurtleff College, emphasized the fact that "Self-reverence, self-knowledge, self-control, these three alone lead to sovereign power," and that self-sacrifice is really "education's highest aim." We may train the hand to be skilful, the eye to be accurate, and the memory to be retentive, but back of these is still the most important of all—a life of which the others are but manifestations, and upon which they depend for their existence—the will, that is, the man. Dr. Edward Everett Hale has spoken words of wisdom on this line when he says:

"One hears a great deal in our time of better education of the hand and eye. All right! But I wish we could always manage in this mere sharpening of the edge of the tool—for it is nothing more—to give the boy or girl a deeper sense of who it is who is to use the tool; how great, how unmeasured, is the power of the boy or girl. If we could lead along boys or girls from day to day in this sense of possible mastery, if we could really make them believe that in the temptations which are likely to befall them, they can really tread on serpents and scorpions and that nothing shall by any means hurt them, we shall not so much mind if the edge of the tool were not of the very sharpest.

"When Daniel Boone made his forest home, he owed more to the strength of the blow by which he drove his ax, he owed more to the precision with which the ax alighted in its preordained place, than he owed to the dangerous sharpness of the tool. And these boys and girls of ours are to succeed or are to fall according as it is the infinite power of the child of God which undertakes the duties of manhood or womanhood.

"This is the true lesson when a great man dies, or a great woman. Little people ask, in a little way, 'How could she do what she did—or he?' The great teachers answer, 'Of course she did it. She was a child of God; she could do what she chose. Of course he did. Sons of God do not stop or turn backward from the plow.' And any boy or girl who will try the great experiment has this victory open. 'I control my body; it shall do what I command. I control my mind. It shall think things which are pure, which are lovely, which are of good report. It shall not think things which are base or mean and in any shape wrong.'

"The boy who makes that determination is a son of God, and as a son of God puts an end to all other notions, in that moment becomes a veritable man. The girl who thus determines becomes a true woman. These two, at least, of us all get an answer to our question.

Self-discipline and self-control are the beginnings of practical wisdom; and these must have their root in self-respect. Hope springs from it—hope which is the companion of power, and the mother of success; for whoso hopes strongly has within him the gift of miracles. The humblest may say, "To respect myself, to develop myself—this is my true duty in life. An integral and responsible part of the great system of society, I owe it to society and to its author not to degrade or destroy either my body, mind, or instincts. I am bound, on the contrary, to the best of my power, to give to those parts of my constitution the highest degree of perfection possible. I am not only to suppress the evil, but to evoke the good elements in my nature. And as I respect myself, so am I equally bound to respect others, as they on their part are bound to respect me." Hence, mutual respect, justice, and order, of which law becomes the written record and guarantee.

DON'T DESERT THE POST.

YOUNG persons are sometimes told that duty is always pleasant. Duty done is always pleasant in the retrospect, but the actual doing of duty not rarely involves the severest self-denial. When real difficulties come, as come they will, do not attempt to escape them by cowardly shifts or by deserting your posts, but face them and conquer them. You cannot escape difficulties if you try. This conquest of difficulties is requisite to generate force within yourselves, and to secure the respect of others. The fighting capacity is just as requisite for a civilian as for a soldier. Life is a battle, and courage and endurance are Christian virtues.

Choose your place of work as carefully as you would your profession. A manly, philanthropic character cannot be developed in a predestined wilderness. You cannot do work for man in a place which economical laws are draining of its population. Go where men instinctively congregate—where there is the sorest need of moral power for the guidance and control of the weak and

the erring. When you have thus pitched your tent, stay till you can command a position against every antagonist. Then, and not till then, may you safely change your base. If you can be driven from one position, you may be from another, and you will fail to forge that firmly knit, elastic, and manly character which is the first condition of conquest.

SELF-KNOWLEDGE.

TRAINING involves a rigid account of oneself based on searching self-knowledge. To become an active speaker one must know his defects of bearing, gesture, voice; one must bring his whole personality into clear light, and study it as if it were an external thing; one must become intensely self-conscious. The initiation to every art is through this door of rigid scrutiny of self, and entire surrender of self to the discipline of minute study and exacting practice. The pianist knows the artistic value of every note, and strikes each note with carefully calculated effect. The artist gives himself up to patient study of details, and is content with the monotony of laborious imitation, subjecting every element of material and manner to the most thorough analysis.

TECHNICAL EDUCATION A SOCIAL FACTOR.

THE work accomplished by the American nation shows gigantic concentration of cosmopolitan energy. Philosophy, science, and experience force the educators of this transitional epoch in the world's history to recognize the reciprocal relations between mental and bodily activity, a fact which now brings prominently enough, and will, early in the twentieth century, bring bodily activity still more prominently into the curriculum of the school, especially in a government by the people, for the people, which must rise or fall according to the mental and bodily condition of the people.

The children of today are born with the highest degree of bodily activity. Any one observing the large, wondering eyes of our children, comparing, seemingly, one object with another, though resting for hours in a peaceful and undisturbed condition, will notice them quite active in thinking, and while their plastic features indicate restful, harmonious bodily development, their gain of knowledge by means of silent observation and evident self-activity, is surprising.

With the power to walk and speak, the child's condition is, however, suddenly changed, and the combined forces of its mental and physical activities break forth without limit. The child wants to know and to do everything at once. His faithful teacher's experimental activity and repetition of comparison and observation seem now too slow, and to the adult he clings in his demands and expectations. What provision is in use to direct and satisfy these childish demands?

Our houses are not built with nurseries fitted to hold experimental toys; as for example, a rocking horse, a nursery swing, nursery gymnastic tools, Australian jumping chairs, colored ellipsoids to sort and string, and, highly important, a sand table. Neither, in most cases, are nurses often, and sometimes not even mothers, capable of answering the questions of the child. Our tenement houses, our hotels, and our single rooms preclude the child from running and jumping. There are very few clean, healthy, and attractive yards; no near-by parks where a mother may sit to sew while the children play around her knees, as seen in Europe; no private parks open to them; no school gardens; no teachers engaged to take the truants, as in London, to the gymnastic apparatus found in the parks, and to the museum or other places of learning and interest. There are only rare possibilities of excursions in field and forest, where teachers can make selections.

What is the fate of these prevented activities? The children are perverted; they are driven out on to those highways of juvenile crime, our streets and byways, where, by eager, idle, practical observation, with a dime novel in each hand and a dime novel in each pocket, their wonderful gifts and activities are, inch by inch, turned into destructive activities, and a contempt for labor gradually grows into distorted views and vicious habits of life.

Our youth should be taught, at an early age, that while, in the first place, they should secure a solid foundation of physical health, the cultivation of the habit of mental application is quite indispensable for the education of the student.

THERE was a fine motto found in the pocketbook of an aged man and wealthy merchant who had been accidentally drowned: "If your hands cannot be usefully employed, attend to the cultivation of your mind."

WHAT SHALL WE READ?

BOOKS are the very best friends or the most merciless enemies of mankind. The man of serious thought and reflection

Finds tongues in trees, books in the running brooks,
Sermons in stones, and good in everything.

He reads those books that help in the development of character, that strengthen his citizenship, and brighten his home powers and purposes. His reading fits him for the better discharge of every-day duties, makes him a more worthy employer, a more successful superintendent, a more trusted foreman, or, on the other hand, renders him a more efficient employe, a more skilled mechanic, a more hopeful and useful workman. A man may be known by his books. Enter the home of the artisan, glance at his books, examine the periodical literature he receives, and you have at once his character, his ambitions, and purposes fully revealed. So much importance did the illustrious Emerson place on the choice of books that he wrote "Be sure to read no mean books. Shun the spawn of the press on the gossip of the home. Do not read what you shall learn, without asking, in the street or on the train. Dr. Johnson said, 'he always went into stately shops,' and good travelers stop at the best hotels; for, though they cost more, they do not cost much more, and there is the good company, and the best information. In like manner, the scholar knows that the famed books contain, first and last, the best thoughts and facts. Now and then, by rarest luck, in some foolish Grub street, is the gem we want. But in the best circles is the best information. If you should transfer the amount of your reading day by day, from the newspaper to the standard authors —but who dare speak of such a thing? The three practical rules, then, which I have to offer are: (1) Never read any book that is not a year old. (2) Never read any but famed books. (3) Never read any but what you like; or, in Shakespeare's phrase,

'No profit goes where is no pleasure ta'en,
In brief, sir, study what you most affect.'"

Emerson again says: "Go with mean people, and you think life is mean. Then read Plutarch, and the world is a proud place, peopled with men of positive quality, with heroes and demigods standing around us, who will not let us sleep. Whenever any skeptic or bigot claims to be heard on the questions of intellect and morals, we ask if he is familiar with the books of Plato, where all his pert objections have once for all been disposed of. If not, he has no right for our time. Let him go and find himself answered there."

Oh, the glorious people of books! Life looks up; the "cares that infest the day" are easier borne in their royal company. When life grows too heavy for you, when you sit in the shadow of the cypress, or with Elijah under the juniper, there is nothing that consoles like biography, except it be the inspired Word. Others have gone into the valley and come out the stronger, as you may do, if you take your chastenings as intended.

When life is joyous, nothing inspires like biography. If you are young, it will make you feel that life is sublime; it will nerve your arm to do and dare; it will convince you that education and force of character have won in all climes and in all ages. It will show you that all ignoble actions burn the soul, and even in this world meet retribution; "that to be right, with God on a side, is to be in the majority"; that to be the vanguard of truth is to stand amid the fires of martyrdom while one writes his name among the stars; that to die for a grand cause is to be forever its living champion; that to live a noble life is greater than to write a grand book or a sublime poem. And whether you follow the sublimest of all lives through the sorrows of Gethsemane into the shadows of Calvary, or stand entranced amid the pomp and magnificence of the court of the Cæsars, the lessons learned from the stories of human lives will make you wiser and better.

THE SIN OF MEDIOCRITY.

THE sin of American labor at the present day is mediocrity; our boys especially are too impatient to begin life for themselves. They start without capital, either in the way of money or education; the result is often disappointment and failure, no matter how willing they may be to work. The future needs and will demand men and women of fixedness of purpose, each one capable of doing some one thing, but doing that one thing better than any one else can do it.

"The best political economy," Emerson tells us, "is the care and culture of men. Culture is not coddling, but training—not help from without, but growth from within. The harsh experience of centuries has shown that men are not made by easy processes. Character is a hardy plant. It thrives best where the north wind tempers the sunshine."

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BECOMES A COLLEGE STUDENT.

Up to the time I was 18 years of age, I had no desire to acquire an education. I enrolled in "The Correspondence School of Mines," and after several years' study, am in a position to speak of its merits. The Course imbued me with the desire for an education, and assisted me in entering the college which I now attend. The professor of drawing at this institution has accepted the drawing I did in the course as equivalent to the Freshman-year course in drawing taught here, and allows me a grade on it. I will say that had it not been for the School, I would today be driving a mule in a coal mine, instead of studying engineering in college.—*Geo. W. Evans* (*F. 182*), *Pullman, Wash.*

SUPERINTENDENT OF A COLLIERY.

Regarding practical benefits derived by me from The International Correspondence Schools, I will say that when I began studying in the Complete Coal Mining Course, I was working as a miner. Since then I have been successful in obtaining a mine-manager's certificate for this Province, and also the School Diploma. I am now employed as superintendent of one of the collieries owned by The Dominion Coal Company.—*P. Christianson* (*C. M. 264*), *Bridgeport, C. B. N. S.*

ELECTRICAL ENGINEER FOR MONCTON, N. B.

I decided to take a course in The International Correspondence Schools during its early days, being No. 10 in the old Electrical Course. I have never had cause to regret my decision. The small amount paid for the course was trifling, compared with the benefits received. I know of some who started in the electrical field earlier than I, and are still where they started, but—thanks to the Schools—I find no difficulty in getting better positions than they. I have no difficulty in installing complete plants of any kind, making all specifications and drawings for them myself. I am now electrician for the town of Moncton, New Brunswick.—*Geo. M. McDonald* (*M. E. 1869*), (*E. 10*), *Moncton, N. B.*

IN CHARGE OF THE DRAFTING ROOM.

COLD SPRING, N. Y., March 24, 1897.
International Correspondence Schools, Scranton, Pa.

GENTLEMEN:—I take pleasure in stating that one of your pupils, Mr. W. O. Dunseith, entered our office five years ago as a boy. He has become a good draftsman; and, owing to the Course he has taken, we find him well informed on subjects which are necessary in our business. He will, no doubt, become a competent designer of machinery, and deserve a good salary. Yours respectfully,

(Signed) G. PAULDING,
Pres. West Point Foundry Co.

COLD SPRING, N. Y., Jan. 9, 1899.
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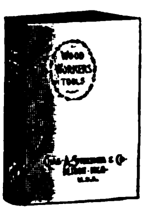

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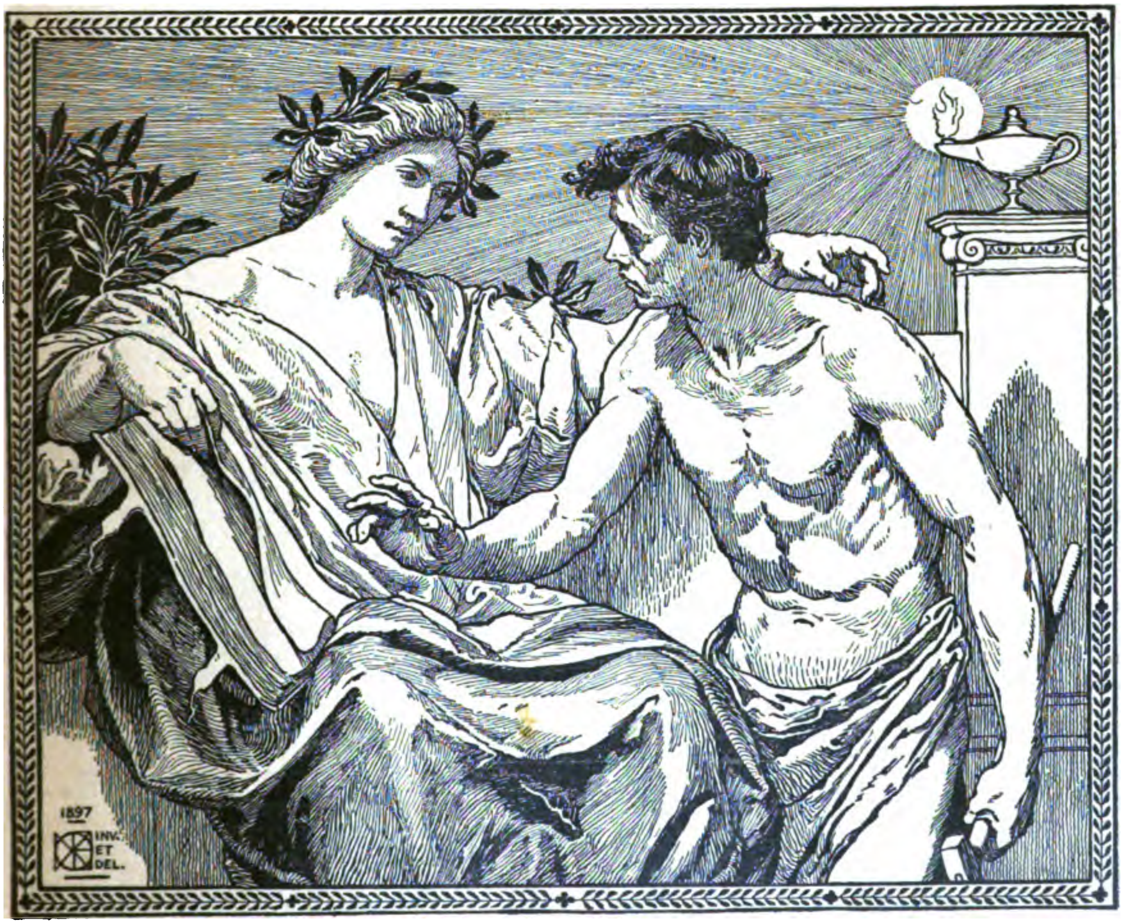

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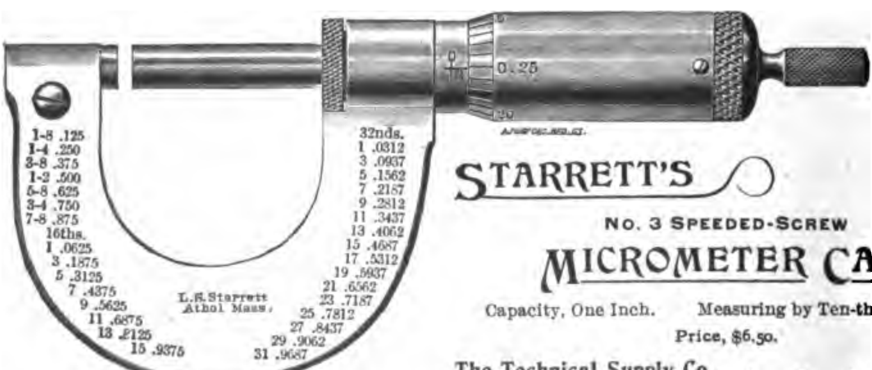

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THE ALPHABET, AND THE ART OF LETTERING.

Chas. J. Allen.

THE ORIGIN OF OUR ALPHABET—PICTURE WORDS OF THE ANCIENTS—EGYPTIAN HIEROGLYPHICS—DISADVANTAGES OF THE CHINESE ALPHABET—HOW TO READ.

PART I.

THE SPHINX AND THE GREAT PYRAMID IN EGYPT.

IS IT foolish to hope that, when the reader sees the title of this article, he will *not* turn over the page in search of something more interesting? Of course, if he knows all he cares to about the twenty-six little signs that he learned, when only about "so high," to repeat from *A* to *Z*, it will be natural for him to leave the article alone; but there are so few people who know anything whatever about them beyond their mere position in the alphabet, that we venture to hope he will have patience and stay with us for a few minutes, while we endeavor to interest him in their history.

No one will deny that the ability to read and write is of vital importance; and it will be admitted at once that it is absolutely necessary to know what the words, either read or written, mean. Yet there are comparatively few people who know *why* a word means what it does. Take the word *lithograph*, for instance; how many recognize, every time they speak it, read it, or write it, the two Greek words from which it was derived, namely, *lithos*, "a stone," and *grapho*, "I write"? And so with the letters of the alphabet: how many, when looking at the letter *a*, recognize in it the Greek *alpha*, and then remember that this was derived from the Hebrew *aleph*, meaning "ox"?

It is because we earnestly wish those who

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are interested in practical lettering to know more than merely how to *form* the letters that we begin with a brief account of their origin, not attempting to deal separately with each individual letter, but to tell in a general way of the various stages in their development, and to show that the letters now used are the result of a slow and gradual growth that began thousands of years ago.

Consider for a moment how closely the growth of the alphabet has been connected with every advance in the general intelligence of man, until now practically everything that is known is written down in one form or another, and that so plainly and by means of so perfect an alphabet that the child may read and understand. Compare this condition of things with that of the ancient Egyptians. If their work had not been left in the form of imperishable monuments of stone—like the pyramids and obelisks—of metal coins, of pottery, and so forth, we would now be in utter ignorance of the early forms of writing, for it is upon them that we find the hieroglyphic records of ancient historical events. Fortunately, the inscriptions upon these relics of antiquity are sufficient to form way-marks through the centuries, and to tell us in brief the history of those times.

It is a generally accepted fact that writing began with rude pictures of objects, made for the purpose of conveying sequences of ideas, and hence termed *ideographs*. The word *ideograph* is derived from the Greek *idea*, which means the same as it does in English, and *grapho*, "I write." The pictures used gradually became mere conventional signs, and finally the letters of an alphabet. But we are going too fast; the process of development was exceedingly slow.

In speaking of the writing of the ancient Egyptians, we have used the word *hieroglyphic;* this is derived from the Greek *hieros*, "sacred," and *gluphein*, "to carve," and means literally "sacred carving or writing." The Egyptians used hieroglyphics to represent either objects or sounds, or a combination of both. This led, as will be shown, to the *phonetic* alphabet now used. The word *phonetic* is derived from the Greek *phonos*, "sound," and means "representing articulate sounds, or speech." Here, the various signs have in themselves no meaning whatever; they merely indicate particular articulate sounds—the number of possible combinations of them, and therefore the number of words that it is possible to make with them, being practically infinite.

At the present time there is one great nation that has never advanced beyond the ideographic period, and this nation—the Chinese—instead of now possessing a condensed alphabet, have, by gradually adding character to character, accumulated a stock of over 40,000 different and independent characters, each representing a single sense of a word. To show, by comparison, the advantage of our system: A boy of 12 years in an American school reads and writes English with a facility that would take a student of Chinese twenty-five years to acquire.

The changes that gradually transformed the first ideographs to the letters now used were of course very gradual, and the earliest of them we know nothing of; indeed, we are satisfied to carry the reader's mind no further back than the hieroglyphic period of the Egyptians. There are positively no records, either in the form of inscriptions on monuments or otherwise, to show that any development of the ideographic towards the present system began before the exodus of the Israelites from Egypt. This carries us back to the year 1491 B.C.—3,390 years ago—and we must remember that prior to this was the hieroglyphic period.

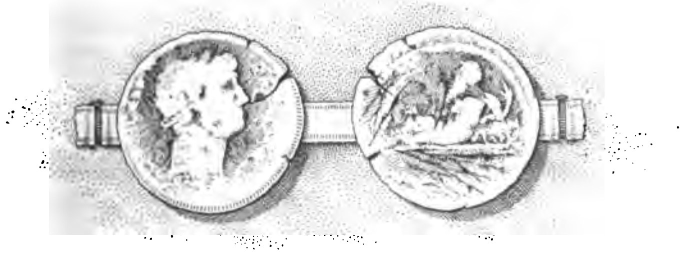
We are indebted to the Phœnicians—a people that occupied a narrow strip of country northwest of Palestine, bordering on the Mediterranean—for the marvelous developments that finally led to the alphabet of today. On account of their maritime knowledge, the Phœnicians advanced beyond the arts of the Egyptians, and gradually developed from ideographs and hieroglyphics certain phonetic signs or letters, the one system drifting almost imperceptibly into the other.

For the benefit of those that are not familiar with ancient history, the mention of a few important events will serve to make this article of more profit and interest. After the exodus of the Israelites in 1491 B.C., we come to an independent alphabet given by the Hebrews; this was followed a few centuries later by the Greek alphabet, as gradually evolved by the Phœnicians. About 540 B.C. the empire of Babylon was established, and between that time and the beginning of the Christian era there followed the Medo-Persian, Grecian, and Roman empires. During these five centuries the policy of the nations was aggressive, as opposed to the tranquility of what may be termed "hieroglyphic Egypt," and great changes were made in the forms of writing.

Through all the changes, however, the permeating influence of the Hebrew is distinctly traceable. The early Hebrew characters were rounded—quite different from the present square characters—but the names of the letters were the same as they are now, each letter having a significant meaning. Where we, in our alphabet, have *a*, *b*, *c*, *d*, the Hebrews have *aleph* (ox), *beth* (house), *gimel* (camel), *daleth* (door); the similarity between the Hebrew and the Greek is very noticeable; thus, in Greek we have for the above, *alpha*, *beta*, *gamma*, *delta;* but these, unlike Hebrew, have no significant meaning.

It would be impossible in a magazine article like this to show by means of illustrations how various ideographs or hieroglyphics were gradually changed until they became letters of our alphabet. Indeed, it is not possible to separate and definitely trace to their origin the numerous forms of writing that have existed, people who claim to see positive identity between even the hieroglyphic and the Hebrew characters having to draw largely upon their imagination. One thing, however, we do know: the great change from a language consisting of thousands of independent picture words, to one having as a complete key a simple alphabet of twenty-six letters, was accomplished, and we, without having done anything but take what was ready prepared for us, constantly benefit by it. We have only to look at China to see the fatal consequences of clinging to the ideographic form. And in this connection it is interesting to note in how many ways we do even now make use of ideographic characters; for example, $, £, ¢, %, =, √, +, —, ×, ÷, @, are ideographs; so are the three balls over the pawnbrokers, the striped pole by which we know the barber's shop, the Indian outside the cigar store; so are the flags of the nations, family crests, trade marks—all of them, ideographs. It is as well therefore to hesitate, before we smile at the ignorance of the Egyptians or pity their inability to write in a manner that is at once intelligible to us. Their language is one of words, ours is one of letters; and therein lies the secret of our ability to flash a cable message telling those in the western hemisphere news of the Orient, so that we may read of an event in the morning paper at an earlier hour in the solar day than that of its actual occurrence; it is these letters that make it possible for the mere tick of a key and sounder to be translated into words and sentences, and thus into a message that the whole world may partake of simultaneously.

One thing every one should guard against, and that is, looking upon words as mere signs or pictures, and forgetting the importance of the syllables and letters. Every word has a derivation, a history; a few derivations have been given here. It should be the aim of every man to know the meaning of every word he uses or reads, not simply "by heart"—that is, from memory—but intelligently. Read what John Ruskin says in his famous lecture on books and how to read them: "And, therefore, first of all, I tell you, earnestly and authoritatively (I *know* I am right in this), you must get into the habit of looking intensely at words, and assuring yourself of their meaning, syllable by syllable—nay, letter by letter. For though it is only by reason of the opposition of letters in the function of signs, to sounds in function of signs, that the study of books is called 'literature,' and that a man versed in it is called, by the consent of nations, a man of letters instead of a man of books or of words, you may yet connect with that accidental nomenclature this real principle—that you might read all the books in the British Museum (if you could live long enough), and remain an utterly 'illiterate,' and uneducated person; but that if you read ten pages of a good book, letter by letter—that is to say, with real accuracy—you are for evermore in some measure an educated person. The entire difference between education and non-education (as regards the mere intellectual part of it) consists in this accuracy."



A Cæsar Augustus Penny Belonging to the Writer.

SURVEYING WITH BICYCLE AND CYCLOMETER.

Louis Allen Osborne.

The Accuracy of the Cyclometer as a Measuring Instrument—Method of Taking Notes—Landmarks—Plotting the Map From the Notes.

IT IS probably safe to say that, as an educator, no machine ever invented has equaled the bicycle. Men, women, and even children have become amateur mechanics on a small scale through their efforts to effect temporary roadside repairs or adjust the bearings of their wheels; while the farmer, impressed with the reports of the several cyclists who daily pass his house, has finally come to acknowledge that even *his* method of reckoning distances does not produce such uniform results as the cyclometer.

Of the hundreds of thousands of bicyclists, whether they ride for recreation or from necessity, there is not one who is not interested in the distance he travels, and in the grade and material of the road. To that extent, therefore, all may be said to become students in geography, surveying, and geology. For long rides through unknown territory, road maps and explicit directions are necessary; the grade and quality of the road will determine the time required to complete the journey, while the geological character of the districts traveled will materially affect the condition of the roads during extremely dry weather and after heavy rains. For instance, in a sandy district, after a week of dry weather, bicycling is decidedly hard work; but two hours after a rain the same roads are in the best of condition. On the other hand, a clayey road is slippery, soft, and often unridable, immediately after a rain, but remains as hard as a pavement throughout the dry season. Ordinary loam roads lie between these, being unridable both in rainy and extremely dry weather, but excellent in ordinary weather. All of these may be considered as geological details that are of interest to the wheelman as a surveyor, and important to him as a tourist.

Unfortunately for the traveler, road maps do not, as a rule, give all this information, and far too often they lead the rider off the track by being inaccurate in scale and distance. These inaccuracies are due to errors of different surveyors and draftsmen in making their surveys and plotting their plans, and can be easily corrected if the importance of the work demands it, which, as a rule, it does not. Now, every man who rides a bicycle, and has attached to it a cyclometer that registers the distance traveled, possesses sufficient instruments to measure and lay out a map of the country over which he travels, and thus, should he so desire, to make a surveyor of himself.

Fig. 1.

True, this map will not be sufficiently accurate to serve as a guide in laying out farm lands, but its distances expressed from town to town will be far more accurate than the traditions preserved among the farmers themselves. Fig. 1 is a map of a portion of Luzerne County, Pa.; it was made from the United States Topographical Survey, and is as accurate as possible in every respect. Such a map, although it costs an enormous sum to produce, and though complete in every detail, is almost useless as a practical road map, because its network of roads and cross-roads and contour lines causes as much confusion as assistance. Besides this, there is no way of telling the number of miles from one place to another without considerable scaling, while information as to the quality of the road is entirely lacking. The chief commendation for this style of map, then, is its accuracy. In Fig. 2 is shown a map of the road from the city of Wilkes-Barre, Pa., to Shawnese Lake, drawn from notes and measurements made with no other instruments than a bicycle and a cyclometer. A comparison of this road between Wilkes-Barre and Dallas, with that shown on the map in Fig. 1, will illustrate the degree of accuracy such a survey may attain; and, for all practical purposes, the map shown in Fig. 2 is just as good and in many ways better than the government survey. Besides, Fig. 2 is more up to date than Fig. 1, as it was made four years after the government survey, and could as a matter of fact be measured, noted, and completed before a survey such as shown in Fig. 1 could be measured around the first square mile.

Now let us consider the method of procedure by which the bicyclist may become a surveyor and thereby able to convert the results of each trip over a new road into a permanent record for future use. In the first place, a word about the cyclometer and its value as a surveying instrument: A cyclometer is not what mathematicians would call an instrument of precision, like the transit, the level, or even the surveyor's compass. It will record with an error of about 1 per cent. when working at its best, and under certain circumstances the error will be increased to 3 per cent. This error is due to the relation between the diameter of the bicycle wheel and the number of revolutions which will cause the cyclometer to record 1 mile.. The usual cyclometer, designed for a 28-inch wheel, requires 720 revolutions of the wheel of the bicycle to cause it to record 1 mile; but, owing to the deflation of the tire and the weight of the rider, the wheel may be but 27.5 inches in effective diameter, and the cyclometer will record 1.019 miles for each mile ridden, or 101.9 miles for each 100 miles traveled. In addition to this error, the bicycle actually travels farther than the true length of the road itself, owing to the fact that the rider continually crosses and recrosses the road in

FIG. 2.

order to select the best parts for cycling, and this error, varying as it does according to the character of the road, will amount to about 2 or 3 per cent. more. Therefore, before we start on our survey, we will assume that our cyclometer measurements will all be 5 per cent. in excess of the actual distances traveled. If the bicycle surveyor be an experienced rider, his map may be so plotted that grades and conditions of road may be readily expressed, and other

information never found on the most accurate of maps may be added as a guide to the future traveler.

The method pursued in this work is somewhat similar to that followed by the army in making military surveys. Odometers attached to the wheels of wagons or other vehicles, pedometers carried in the pockets of marching soldiers, and even cyclometers on bicycles are used at the present time to make surveys of roads and territory for the use of a moving army. In practical work the signal corps and surveyors move one or more days in advance of the army, survey the roads and surrounding country, leaving with or sending to the commanding officer in the rear a reconnaissance map of same. In some instances it has been desirable that the field telephone and telegraph, laid by the signal corps as they march, should be used to communicate the survey notes back to headquarters, where a preliminary map is plotted. Thus, in military surveying, it will appear that the notes must be extremely simple, and the method of taking them rapid and positive. The method of bicycle surveying here explained is simpler than even military work, as from the former is eliminated entirely the use of surveying instruments, such as the compass, sextant, hand level, etc., which military surveyors depend upon extensively. The notes in this work are simpler, as they appertain almost exclusively to road surveying, while the military map must show other details, such as farm lands, grain fields, orchards, cattle houses, poultry yards, etc., to furnish information of value to foragers, which would not be required by the tourist.

The next detail to consider is the note book. This should be long and narrow, with two parallel lines ruled down the center of the page to represent the road. Stenographers' note books serve the purpose admirably; these are about 4½ inches wide and 8 inches long, and are ruled across the page with lines about ½ inch apart; the two parallel lines down the center of each page can be ruled with either pencil or pen, and the book is then ready for the trip. A piece of board, the same size as the book, should be secured to the handle bars, and the book laid on and bound fast with rubber bands. A bicycle watch on the handle bar is also a great convenience, but by no means a necessity.

The arrangement will now look somewhat as in Fig. 3. At *a* is the cyclometer, the record of which should be easily read by leaning over the handle bars; at *b* is the note book, and at *c* is the watch, which will act as a check on the cyclometer and grade notes. Now, we will assume that the bicyclist is out on a trip with a number of other enthusiasts, and, therefore, will be unable to stop and make any individual measurements of the roads and landmarks which he passes. All notes must be made awheel, and information recorded without slackening speed. Before he starts, the register of the cyclometer is observed, and written on the lowest line of the note book and is found to be 2,388.8 miles, as shown

FIG. 3.

in Fig. 4. In recording subsequent cyclometer readings it will not be necessary to note the thousands and hundreds of miles, except when these figures change.

The surveyor starts out through the main street of Wilkes-Barre, and as he crosses the river he notes that his cyclometer reads 2,389.05 miles, and on the second line from the bottom he marks this record, as shown in Fig. 4, and at the same time draws two wavy lines across the road to indicate that it was while crossing the river that he recorded this reading. Soon he arrives at the Kingston cross-roads, and there turns to the right; his cyclometer reading is recorded as 90.24, and, branching from the right of the central column of his note book, he indicates the road he takes with an arrowhead as shown, while on the left he shows a similar cross-road with no arrow. Observe, also, that his note book does not show this cross-road as

branching at a right angle from the road he is traveling, but is drawn according to his judgment, at *about* the angle it actually makes. On the opposite side of the road, on the corner, is an old tavern, and he marks a rectangle to indicate it in his notes as shown. Village streets branch from the main road through Kingston, and these he indicates as he passes as shown in the notes at cyclometer readings 90.39 and 90.44. At 90.99 he arrives at the village of Dorrance, takes the left branch, and rides straightaway to 91.85—in the village of Luzerne—where he takes the left branch for a little way and then at 92.25 the road itself turns slightly to the right.

This indication of a bend in the road is made simply by drawing, in the central column, two straight lines, intersecting at about the angle of the bend of the road, as shown in Fig. 4. In general practice, slight bends in either direction are not considered; but, where a bend or a branch of the road is but a trifle less or a trifle more than a right angle, this shortage or excess should be indicated by a plus or minus sign, as shown on the branches at Kingston and Dorrance 90.24 and 90.99. At 92.70 the road bends to the left, and at 92.80 it turns to the right, while at 93 it turns at right angles as indicated. At 94.15 the road forks, and the tourist takes the right fork, as indicated by the arrow. Soon he crosses a stream, as indicated by the wavy line at 94.58, and $\frac{2}{10}$ of a mile beyond he passes through Truckville, and takes the right fork of the road out of that village. At 96.72 there is a branch road back and to the left, which the rider takes. At 97.93 there is a similar branch road to the left, and at 98.10 there is a branch road to the right in the village of Dallas.

We have only considered here the distances and the roads, while on the left of the note book are a number of entries of landmarks that give additional value to the directions when used by some one else than the original surveyor. The cross-hatched line at 92.25 indicates that there is a railroad crossing there. At Mill Hollow is shown a small rectangle to the right of the road, while marginal notes on the left of the page indicate what stands in the place so marked. The time of arrival at and departure from different places, as marked on the left of the page, is also of value, as showing the general character of the roads traversed. For instance, from Wilkes-Barre to Kingston, a distance of $1\frac{1}{2}$ miles, covered in 7 minutes, indicates a good piece of fairly level road, and the same may be said of the stretch

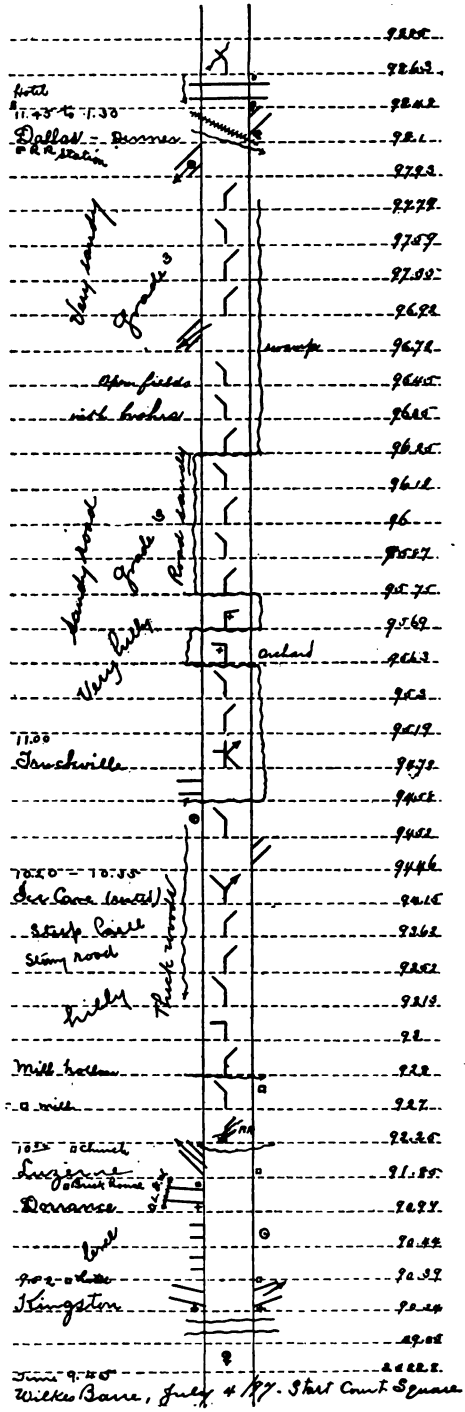


FIG. 4.

from Kingston to Luzerne; but the distance from Luzerne to Ice Cave, 2⅛ miles, required 35 minutes, which, together with the fact that a rest of 15 minutes was taken at Ice Cave, would indicate a rough road traveled. The circles with dots in the center indicate the position of the sun, at various points on the road, so that, with the notes regarding the time of arrival at different stations, a fair idea of the points of a compass may be obtained. At the start the sun was directly behind and shining down the street at 9:30 in the morning, which would indicate that the road ran northwest and southeast. From Kingston to Luzerne the sun was on the right, while, before taking the right fork beyond Truckville, the sun was on the left. At Dallas, where stop was made for dinner between noon and 1 o'clock, the sun was in the direction shown by the circle and arrow, which may be considered as due south. Other details of the notes will be considered during the explanation of the plotting of the map.

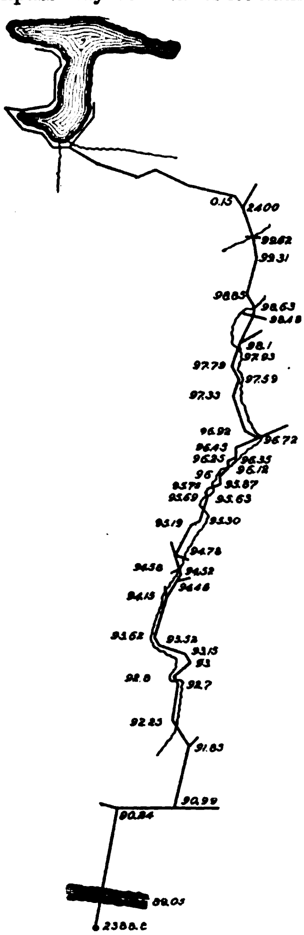


FIG. 5.

As a usual thing it is desirable that the bicyclist surveyor should travel homeward by another road, so as to continue his notes and make his round trip a complete survey without repetition; but we will not concern ourselves with the return trip at present, but proceed to plot our map from his notes here given.

A scale of 1 inch to the mile is a good size for practical purposes, and we will proceed on this scale to draw a map. It is apparent from our notes that the road from Wilkes-Barre to Kingston, 1½ miles in length, is practically straight; therefore, we measure off 1½ inches on our drawing paper and lay off this piece of road, marking in small numbers the beginning of it as 2,388.8 and the end of it 90.24, as shown in Fig. 5. Somewhat more than ¼ mile out, we cross the Susquehanna River; therefore, at 89.05 we draw the river crossing the road at right angles. At station 90.24 we indicate the road branching to the right and left, and continue the right branch until it measures 3 miles from the beginning. This takes us to the village of Dorrance, which is marked in our notes as 90.99, where we turn to the left at an angle slightly in excess of a right angle, as indicated by the plus mark, and plot our road to 91.85; here the road forks to the left, and we continue through Mill Hollow, a small settlement that evidently takes its name from an old mill on the right of the road, as indicated by the notes. Here the road crosses a small stream, turns to the right, and at station 93 takes a sharp turn at right angles to the left, which, with a subsequent half turn to the left, and two half turns to the right, brings us to another small settlement called Ice Cave, 94.15. About 2 miles from here, after crossing a small creek, we arrive at Truckville, indicating the creek by a wavy line, and then plot the road to Dallas. The creek may now be continued parallel to and on the right side of the road and up to 95.63, where it crosses the road to the left side, but recrosses and returns almost immediately. When the cross-road at Dallas is plotted, particular attention must be given to its direction, as, according to the indicated position of the sun in the notes, this road should run north and south, and any errors in the previous lines should here be corrected.

The rest of the road up to the lake is similarly plotted and the road around the lake sketched in; then the lake itself may be drawn, as the road extends along its border and is governed largely by the outline of the lake itself. Thus, a complete and satisfactory survey of the road may be plotted in an hour, from notes which were taken without the slightest loss of time on the trip. Subsequent trips and similar surveys of other roads in the vicinity, when plotted, will be found to fit in one with another, and thereby make a most satisfactory map, as shown in Fig. 2. The bicyclist is rendered more observing by work of this

character, he sees every detail, he notes every bend in the road, and in a short time he unconsciously searches for some landmark by which he can identify a certain piece of road, either for his own or some one else's use. In making notes on a trip, it is always wise to assume a certain definite angle which will indicate a bend in the road.

Where a road crosses or changes its direction at right angles to the course pursued by the rider, the record is not difficult; and even where the deviation or crossing is at an angle of 45°, there is little chance of error; but for angles between these it requires a trained eye to judge them with accuracy, and they should be recorded as 45° or 90° turns, according to which they are nearer to; but a slight deviation from a right angle should be indicated where such exists, and a plus or minus sign marked, in order that the figures may plot more satisfactorily. Always note everything possible. On a road map, a landmark is often more important than roadbed or distances. At every cross-road, fork, or abrupt turn, identify a landmark. This may consist of an "old tree," a "church," a "red barn," a "stone mill," or any object which may in a few words be described as a monument to locate a particular point in the survey. Always show streams of water when they run parallel to or across the road, and indicate which way they flow, for such details give information as to the grade. Where a road is through a thick wood, indicate the fact, as such a road is seldom ridable after heavy rains, and is usually in good condition when other roads are dry and sandy. Be sure to show springs, water troughs, etc., as they serve as resting places where refreshments may be taken, and at the same time act as landmarks to assure the traveler that he is on the right road according to his map and directions. The complete bicycle survey of this road, as far as recorded in our notes, is shown between *a* and *b* in Fig. 2, together with other surveys made of neighboring roads. Note the location of streams and connections from streams of one survey to similar ones in the next, thus completing these little waterways and showing the grades of the locality. All of this may seem a great deal to do when a man is on a pleasure trip, and, to a certain extent, it is; but it gives him educational as well as recreational benefits from the trip, and he is putting his efforts to practical use. In a ride of 18 miles it certainly will not require much effort to make two or three note-book entries each mile, when the book is strapped in front ready to receive them, and yet that is about what the entries average in the accompanying illustration. Let the scheme once be tried, and, after an honest effort at making a bicycle survey, few men will give up the work, as it possesses a fascination second only to bicycling itself.

IN THE WORKSHOP.

(Continued from the March, 1899, Number.)

H. Rolfe.

Remedies for a Slipping Belt—Care and Management of Belting—Hair Versus Flesh Side of Leather—Unsteady Running—Taking Up for Stretch.

"We were talking the other day," said Tom (continuing the conversation recorded in our last), "about wrought-iron pulleys whose rims were in bad shape. I should think that, where a rim was hollow or where its diameter was greater on one side than on the other, the pulley might be made serviceable by gluing around it a piece of leather, of such width and thickness as to correct the error in the rim itself; after the glue has set, the leather could be pared down so as to have the proper profile."

"Well," said Blunt, "in a case like that, always figure the cost first; if you think it will pay, why, do it; if not, get another pulley. Where a rim is exactly the right shape, a leather covering, to increase the driving power, is all well and good; otherwise, it's a botch job; and as a general rule the most economical thing to do—in the long run—is to put up a new pulley."

"Yes, sir, I guess that's so. By the way, about cleaning and caring for belts: you promised to give me some pointers in that direction."

"Well, I'm glad to see you haven't forgotten it, for there's lamentable waste in some shops through neglect in that direction. A belt, after being in use for a time, acquires a hard, smooth surface. Then, naturally, it begins to slip, which makes the surface worse. Then the man in charge tightens it up. The improvement, if there is any, is only temporary; so, very soon, more tightening is resorted to. But this tightening of the belt means more pull on the bearings—both when working and also when running on the loose pulley, and this means a waste of power and oil—an especially unnecessary waste when the belt is on the loose pulley; it would be a good thing, in fact, if the tension could then be released altogether."

"Why not make the loose pulley a trifle smaller in diameter than the fast one?"

"Well," said Blunt, "as a matter of fact, that is done on some jobs. You will find an instance on the traveling crane in the erecting shop. The belt pulleys for traveling, cross-traversing, and hoisting are arranged in that way. The loose pulleys are all 16 inches in diameter; while the belt is on one of them, it is comparatively slack; the fast pulleys are 16¼ inches in diameter, and are beveled down on the inner edge, so that the belt shifter has no difficulty in sliding the belt on to the larger pulley, where it immediately becomes taut enough to take hold of its load."

"But don't you think it's a bad thing for the belt itself to vary the strain on it in that way? Wouldn't it last longer if kept at the same tension all the time? Take the case of a fiddle string: it doesn't do to let *that* down every time you stop playing. I happen to know that, because my brother, who tortures the catgut under the impression that he's making music, used to slack his E string down before putting the instrument away for the night, and soon found that the next time he played he was sure to have trouble trying to keep that string up to concert pitch. The only way to make it hold its note was to keep it right up to pitch *all* the time."

"That may be so," said Blunt, "but a fiddle string isn't a leather belt; we don't want to keep a belt in *tune;* the object is to make it *last* as long as possible, and I'll bet dollars to doughnuts that a leather belt will last longer if slacked off when not in use. This might or might not be so if there was merely a straight pull throughout the length of the belt; it is the continual bending and unbending around the pulley that wears the belt out, and the less the pull the less this bending effect; in any case, however, there is a saving in oil, and less wear on the bearings. But we are getting away from the subject. I was speaking of the very bad practice of continually tightening up a belt to make it do its work. Now, instead of doing this, you should take the belt *itself* in hand, and restore its proper surface. Any belt, after being in use for a certain length of time, will get smooth and hard. Wait till shutting-down time on Saturday afternoon; then wash the belt well. Use warm water, with a little soda, and let it soak well into the surface of the belt. You'll find that the dirt and stuff will come off readily enough, and leave the surface of the belt clean. Let it dry thoroughly, and on Monday morning, before starting up again, give it a good coat of dubbing. Belts that run in warm places, such as engine rooms, will naturally get dry sooner than others, and will be all the better for a coat of dubbing every three or four months. Dubbing to a dry belt is like water to a parched soil.

Sometimes you are bothered with *oil* on a belt; maybe the cup on a loose pulley leaks and lets the oil down the arms on to the rim; or it works out of a bearing and travels along the shaft and so reaches the pulley. Dynamo tenders could weep with you on this score. A dose of powdered chalk will mend matters; don't put it on with a shovel, though; keep it in a tin can that has half a dozen holes punched in the lid.

"It always pays to look after belts, especially those that have continuous hard work to do. About every eight or nine months, give every belt a coating of dubbing, and then put on two or three coats of boiled linseed oil. The dubbing preserves the leather, and keeps it soft and pliable; the oil oxidizes and forms a gummy surface on the belt—a sticky, clammy surface which holds on to the pulley in great shape. You can easily picture to yourself how such a surface lies down upon and clings to the face of the pulley, coming in close contact everywhere, like a boy's leather sucker on a brick."

"Talking of surfaces, what is your opinion, sir, about running the belt with its hair side against the pulley, instead of the flesh side?"

"Well," said Blunt, "it always seems to me wrong to run the hair, or grain, side next to the pulley. It's working against nature. If you take a piece of leather and bend it first one way and then the other, you will find that it bends much more easily when the flesh side is inwards, and it is perfectly

natural that it should, too, for that is how it had to bend when it was on the cow. No, I'm talking seriously. Take a thin strip of leather, and stretch it forcibly; then lay it down on the bench and watch it; soon you will see it begin to curl up with the flesh side inwards. All this points to the propriety of running the flesh side next the pulley, so that the continual bending shall be in the direction that is natural to the leather itself."

"That seems plausible enough," said Tom, "but I've heard that the driving power is greatest with the hair side next the pulley—as much as 30 per cent. more, some say."

"Well, perhaps so, but I can't see where the extra holding power of the hair side comes in, unless, being smoother and more even, the contact is more perfect. But the tensile strength of the belt is reduced by bending it against the grain. Then again, by a proper use of dubbing and boiled linseed oil, as already explained, the flesh side can be very much improved; the treatment 'kinder' fills up the cracks and uneven places, and produces an A-1 surface. Anyway, whatever else you may do, keep the resin keg under lock and key and have a savage dog alongside to guard it."

"All right, sir," said Tom, laughing at his foreman's emphatic utterance. "By the way," he went on, "I was in the North works the other night—they were working overtime—and I noticed that the main driving belt in the turnery ran very unsteadily; the slack side had a kind of wavy motion, up and down. What do you suppose caused it to run like that?"

"Well," said Blunt, "there are, in the main, two things that will cause it: the engine doing irregular work; and the off-take of power from the driven shaft being uneven. We'll take the engine first: If one side of the piston is getting more steam than the other, *impulses* will be generated that will give the flywheel an uneven speed—unless the wheel is heavy enough to counteract the tendency—and this 'snatching' action will be communicated to the main shaft, and so cause the belt to undulate on the slack side, and sometimes, if severe enough, on the tight side too.

"Then, with regard to the driven shaft, if this is belted up to a machine that takes the power off at successive intervals instead of continuously—as, for instance, when driving a circular cold saw where the saw is out of true and cuts during only a part of each revolution—the belt will soon begin to undulate, and the only way to prevent it is to true up the saw."

"I see. But with regard to the engine, why is one end of the cylinder allowed to do more work than the other?"

"It shouldn't be. But getting more steam doesn't necessarily mean doing more work, unless it's the front end of the cylinder that gets it. You see, the crank-side of the piston has less effective area than the front, owing to the presence of the piston rod. Now, by an unhappy coincidence, it is this very side that gets the least steam, owing to the fact that the action of the connecting and eccentric rods effects an earlier cut-off at the crank-end, the piston's motion being slower and the valve's quicker than at the front end. This can be, and of course is, remedied by the valve setter; in fact I always used to give a little more steam at the crank end to make up for the piston rod's being there—a proceeding doubly necessary in a vertical engine, where the moving parts have to be lifted every time.

"But there is still another thing that will cause a belt to undulate, and that is an unbalanced pulley. A pulley should be perfectly balanced before it is put up, otherwise, in attempting to rotate around its own center of gravity, it will cause the shaft to wabble and the belt to run unsteadily."

"How about the stretch of belts, sir? Our belt tender says that it doesn't matter who you get them from, they all need frequent taking up for the first month or two."

"Yes," said Blunt, "they're all alike in that respect. A leather belt that won't stretch is about as great a rarity as an all-wool shirt that won't shrink. The fact is, the only way to stretch a belt is to run it on pulleys and do work with it; so, whatever the makers may say about the belt being 'non-stretchable,' you must expect to have to take it up after two or three days' running, and then at intervals for the next few months. Link belts are particularly bad offenders in this respect; you see, every one of the numerous pins 'sets' a little in its link, under the pull, the aggregate amount being considerable. In an 80-foot link belt, you will be lucky if, during the first two weeks, you don't have to take out at least a foot of stretch. There's one thing, though, it's easier to shorten a link belt than an ordinary one, which again goes to prove that 'there's a bright side to everything,' even to a leather belt."

(*To be Continued.*)

SLIDING FRICTION.

G. Herbert Follows.

A CONSIDERATION OF THE WELL-KNOWN LAWS WHICH GOVERN RESISTANCE DUE TO SLIDING FRICTION—HOW TO USE A COEFFICIENT OF FRICTION.

PRESS together the palms of your hands, then try to slide one palm over the other. You find that before sliding begins you have to overcome a resistance, and that the more forcibly you press them together the greater the resistance is. As every one knows, this resistance is called *friction*. To distinguish this particular kind of friction from others—such as *rolling* friction—it is called *sliding* friction.

The purpose of this article is to point out in a practical manner the influence that sliding friction has on the design and efficiency of machinery.

There are few books on machine design that do not describe some kind of winch, or crab, as an example in leverage. Fig. 1 is taken from a well-known text-book in which it is explained that the leverage obtained by the combination of crank, gears, and drum shown is 150, and that, therefore, "neglecting friction," a force of 10 pounds applied at the crank will raise a load of 1,500 pounds suspended from the hook. Now this is quite true, and, as an example of what leverage does for us in machinery, it is excellent. Unfortunately, however, many beginners find this part of their studies far too easy, and pass over, as of but slight importance, that little clause "neglecting friction." Later on, they read that friction varies directly as the pressure between, and is independent of the areas of, the surfaces in contact, and so on—getting possibly a fair idea of what a *coefficient* of friction is, and then passing on to other studies.

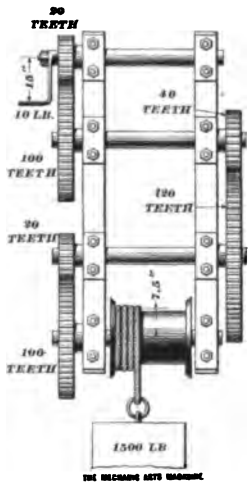


FIG. 1.

But the time comes when the young student is engaged as a draftsman, and is asked to "put some figures" on, say, a hoisting mechanism. Then he refers with feelings of diffidence to his Nystrom, Haswell, Trautwine, or Kent, for a coefficient of friction; and then—to use a little slang, he gets "all balled up." Some of the figures that have been put on hoisting mechanisms are truly wonderful in their simplicity. Here is a favorite way of calculating the lifting capacity of the winch shown in Fig. 1. Neglecting friction, 10 pounds at the crank-handle will raise 1,500 at the hook; coefficient of friction for steel on cast iron—taken from a table in one of the note books aforesaid—.10; loss by friction, $1{,}500 \times .10 = 150$ pounds; actual lifting capacity, $1{,}500 - 150 = 1{,}350$ pounds; whereas, in all probability, 10 pounds at the crank-handle will not raise more than 1,000 pounds. But we shall return to this problem later; there are many things we must understand before we can hope to solve the problem correctly.

First of all it is necessary to know just what the laws already referred to mean; because, although the laws, as stated, are true, they are frequently misunderstood and misapplied. Here, a few very simple experiments will help: In Fig. 2, a is a cast-iron block; p is a cord, by means of which, and through the spring balance s, the block may be dragged about over the cast-iron surface m. The weight of a is 10 pounds, and the condition of the surfaces in contact is supposed to be such that a force of 1 pound—as indicated by the spring balance—is just enough to overcome the frictional resistance and thus to move the block in the direction of the pull.

In Fig. 3, there is the same apparatus, but a block b, also weighing 10 pounds, has been placed on top of a; it is now found that a force of 2 pounds is just enough to move the blocks. Thus, doubling the pressure between the surfaces in contact doubles the frictional resistance. In Fig. 4, another 10-pound block has been added, and, as indicated by the spring balance, the frictional resistance then becomes 3 pounds. In

other words, trebling the pressure between the surfaces trebles the frictional resistance. This direct relation between the pressure and the friction is the meaning of the first of the laws under consideration, which is: *Friction varies directly as the pressure between the surfaces in contact.*

The second law is: *Friction is independent of the areas of the surfaces in contact.* A misapprehension of what this law means has led many a good draftsman into trouble, and the reader is therefore asked to follow with care what is said about it.

When describing the experiments represented in Figs. 2, 3, and 4, no mention was

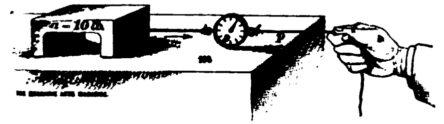


FIG. 2.

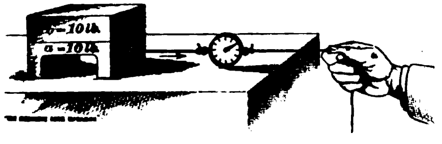


FIG. 3.

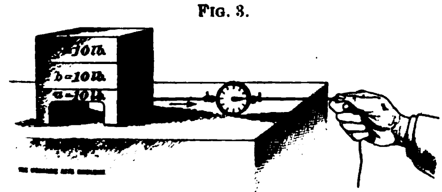


FIG. 4.

made of the area of the surfaces in contact; this was because the point then under consideration had to do merely with pressure and resistance. Throughout the experiments, the block remained resting upon its two narrow feet, and evidently the size of these feet had nothing whatever to do with the three results obtained. But suppose we turn the block over, so that it rests on its large flat surface, as in Fig. 5; what then? Well, if the smoothness of the large surface now in contact with m is exactly the same as the smoothness of the two feet, the force required to move the block will be precisely the same as it was before. And that is what the second law means; but we have not finished with it yet. Before going further, however, something had better be said about *coefficients.*

A coefficient of friction is the ratio between a frictional resistance and the pressure that causes it. Thus, in the first experiment the resistance is 1 pound; the pressure that causes it is 10 pounds, and the coefficient is $\frac{1}{10} = .10$; in the second experiment (the surfaces in contact being the same, the coefficient should be the same), the resistance is 2 pounds; the pressure that causes it is 20 pounds, and the coefficient is $\frac{2}{20} = .10$, as before. A coefficient is used in the following manner: If the pressure between two surfaces is 500 pounds, and we know that for those surfaces the coefficient of friction is .07, we ascertain the frictional resistance by multiplying the pressure by the coefficient, and we get $500 \times .07 = 35$ pounds. Coeffi-

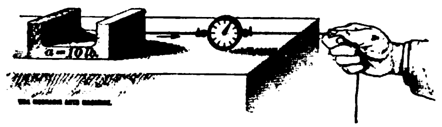


FIG. 5.

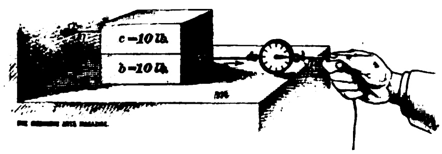


FIG. 6.

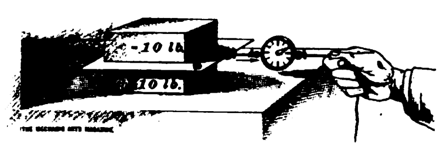


FIG. 7.

cients of friction are found by experiment, and cannot be determined in any other way.

To return, now, to the second law: An experiment with the 10-pound blocks b and c is represented in Fig. 6; the pulling cord is attached to b, and c is placed on top of b; but c is restrained, in the manner shown, so that it cannot move in the direction of the pull on b. The condition of the surfaces in contact is supposed to be the same as before; the coefficient of friction, then, is .10. Bearing the second law in mind, what fractional resistance will there be? Well, it might at first sight be supposed that, as the total pressure on m is 20 pounds, the resistance would be $20 \times .10 = 2$ pounds. But the spring balance indicates 3 pounds; and it is right, for the following reason: There are two distinct and separate resistances, because there are two distinct and separate pairs of surfaces in contact, namely, bottom surface

of b with m, and top surface of b with c. Between the first of these pairs, b and m, there is a pressure of 20 pounds; this pressure produces a resistance of $20 \times .10 = 2$ pounds. Between the second pair, b and c, there is a pressure of 10 pounds, which produces a resistance of $10 \times .10 = 1$ pound. It is the sum of these two amounts that constitutes the total resistance, and this equals $2 + 1 = 3$ pounds, which agrees with the spring balance. In Fig. 7 a similar but still more striking experiment is illustrated. There are the same 10-pound blocks b and c, both of which, however, are prevented from moving in the direction of the pull; between them is a sheet of tin d, supposedly so thin as to have no appreciable weight. The coefficient of friction is again taken at .10. What force will it require to slide d in the direction of the pull? It might at first be supposed that, as the pressure between b and c is but 10 pounds, the resistance would be $10 \times .10 = 1$ pound; but the spring balance indicates 2 pounds, before the sheet of tin begins to move. The explanation is the same as before. There are two separate pairs of surfaces in contact, namely, top of d with bottom of c, and bottom of d with top of b. Between each of these pairs there is a pressure of 10 pounds, thus producing two separate resistances of 1 pound each, or a total resistance of 2 pounds.

This *multiplication* of the *pairs* of surfaces in contact must on no account be confused with the *areas* of the surfaces that *are* in contact; the experiments already performed prove that they are two very different things.

(*To be Concluded.*)

DEVELOPMENTS, OR LAYOUTS.

(*Continued from March, 1899, Number.*)

D. C. Reusch.

FURTHER APPLICATIONS OF THE PRINCIPLE OF ROLLING, WHEN MAKING LAYOUTS OF CURVED SURFACES—THE ACTUAL GEOMETRICAL LAYOUT OF A CARDBOARD LAMP SHADE.

TO OBTAIN the layout of the curved surface of the cone in Fig. 7, we proceed in a manner similar to that already explained in connection with Fig. 5; that is, we place the cone so that the diameter ab is vertical, and imagine it rolled until the other end of the diameter reaches the paper. It is evident that, while rolling, the cone describes part of a circle around the center c; the

FIG. 7.

dimensions of the surface thus rolled over are easily obtained; with radius ac or bc, draw upon the paper a circular arc ba, and make the length of it equal to half the circumference of the base of the cone; then draw straight lines from the ends of this arc to the center c. The surface thus outlined is the layout of one-half of the curved surface of the cone, and the other half is obtained by simply repeating the operation on the opposite side of the center line bc.

We see then that, so long as we have to do with symmetrical bodies from which no parts have been removed, it is quite easy to make all necessary constructions and calculations, and thus to obtain layouts of their surfaces. But when a body is no longer symmetrical, when certain parts of it have been cut away, the necessary constructions seem rather difficult. In reality, however, they are quite as simple—though, it is true, a little more extended than before—and if the principles explained in reference to Fig. 6 are fully understood, no serious difficulty will be experienced.

In Fig. 8 we have an example of this kind—a cylindrical pipe from which certain parts have been cut away, the openings left being clearly marked $a b b_1 a_1$ and $a_2 b_2 b_3 a_3$ in (c). As shown at (b), the distances $a a_1$, $a_1 a_2$, $a_2 a_3$, and $a_3 a_4$ are all alike, being each equal to one-eighth of the circumference of the pipe. To make the layout, we proceed at first as if the pipe were complete, and find the points a and c on the paper which the cylinder, if rolled, would mark out. Then we draw lines $P a_1 c_1$, $a_2 c_2$, etc. at distances apart equal to those on the cylinder. (The

reader will here note that when, in what follows, a measurement or string of measurements is prefixed by the letter P, as in the last sentence, it means "on the paper"; similarly, when a measurement is prefixed by A, it means "on the body." This will

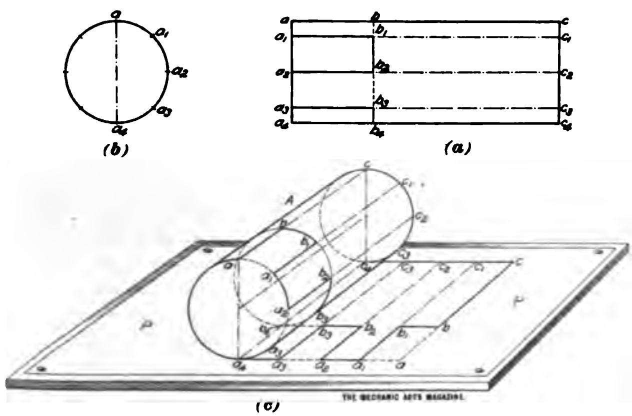


FIG. 8.

save the constant repetition of explanatory clauses.) Referring to Fig. 8 (a), the lines $b\,b_1$ and $b_2\,b_3$, being in line with each other, constitute parts of the circle $b\,b_4$; and this circle will roll along the line P $b\,b_4$ (c), and the intersections of this line with P $a\,c$, $a_1\,c_1$, etc. locate the points P b, b_1, b_2, etc., and thus give the outlines of the openings P $a\,b\,b_1\,a_1$ and $a_2\,b_2\,b_3\,a_3$, completing the layout.

In Fig. 9, at (a) and (c), are shown a side and a perspective view of a piece of pipe that is intended to be joined at right angles to a similiar one. It is desired to outline a pattern from which a pipe of this form and size may be made; to do this we again use the principles explained with reference to Fig. 6. We select a certain number of equidistant points around the slanting end $b\,f_4$, and find the position of these points on the plane of the paper over which the pipe is supposed to roll; this is done in the following manner: Describe, as at (b), a circle representing the end view of the pipe; divide this into any convenient number of equal parts—say eight—and project the points of division to the slanting end of the cylinder, as shown in (b), thus obtaining the lines $a\,f$, $a_1\,f_1$, $a_2\,f_2$, etc., cutting the edge $b_4\,f_4$ at certain points $b\,c_1\,d_2\,e_3\,f_4$. Proceeding now as if the pipe were complete: If, through each of these points, we imagine a circle, as $b\,b_4$, $c\,c_4$, etc., and then imagine the pipe rolled over the paper as before, these circles will imprint on the paper lines $b\,b_4$, $c\,c_4$, etc., as shown at (c); then all that remains to be found is the location of the points in question on these lines. The point A b in (c) can lie nowhere else than at b on line P $a\,f$; point A c_1, being the point of intersection of line A $a_1\,f_1$ and circle $c\,c_4$, must also be the point of intersection of P $a_1\,f_1$ and P $c\,c_4$, and so on; in this manner the points P $b\,c_1\,d_2\,e_3\,f_4$ are located. The curved line passing through these points completes one-half of the required layout; the other half is a counterpart on the opposite side of the center line.

The layout of the curved surface of a cone that has been cut away as shown in Fig. 10 at (a) and (c), is obtained in a similar manner, and it should not be necessary to repeat the explanations. It is perhaps as well to point out, however, that the distances between the construction circles, as between $a\,a_4$ and $c\,c_4$, in (a), must be measured along the

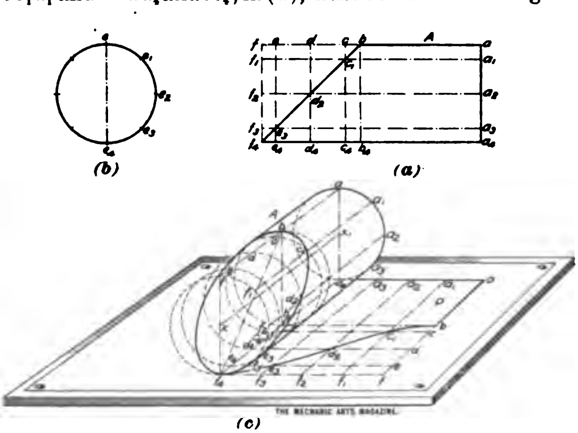


FIG. 9.

slanting surface, and not along the axis; the reason for this is evident. If the cone rests with line $b\,e_4$ in contact with the paper, the distances along this line only should be considered; confusion is thus avoided. The distance P $a\,c$ between the circular curves P $a\,a_4$ and $c\,c_4$ must therefore correspond

with A $a_4 c_4$ of (a) and not with $a_2 c_2$. In other respects, Fig. 10 is self-explanatory.

In Fig. 11 is shown the construction by which the layout of the curved surface of a cone with a slanting base is obtained. The reader should find no difficulty in following the method employed; the only practical

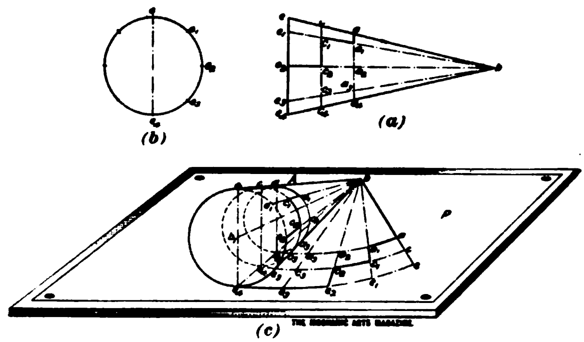


FIG. 10.

difference between this and the layout of the pipe of Fig. 9 is that with the cone the construction circles roll along circular arcs P $a\,a_4$, etc., instead of along straight lines.

So far, the various layouts and constructions described have been illustrated with the aid of perspective drawings, the idea having been to represent the subject in a manner intelligible to all. To those who are not familiar with both perspective and mechanical drawing, it may not be quite clear, as yet, how an actual constructive drawing should be made; for this reason it is deemed advisable to take one more example, and in it to show the whole construction as it would be made in practice.

Supposing it is required to construct a lamp shade of tin or paper, and of the form shown at (a), Fig. 12. We consider this shade as a truncated cone—that is, as a cone with its top cut off. It will be noticed that the base is not at right angles to the axis. We begin by drawing a side view of the shade, as at (b), indicating by dotted lines the outline of the complete cone, and ascertaining by actual measurement the dimensions that, in addition to those given, are required to make the layout.

In previous examples we have in every case drawn a complete end view of the solid under consideration; in actual constructive work this is not absolutely necessary; a half-end view is sufficient, its sole purpose being to enable the draftsman to locate, by projection upon the side view, lines dividing the surface to be developed into the required number of equal or proportional parts. In the present case, then, we describe a semicircle on the base of the cone and divide it into the required number of equal parts—say four—thus obtaining points $g_1 g_2 g_3$. By the projection of these points to the base $g\,g_4$, points A $g_1 g_2 g_3$ are located, which must then be connected to the apex a by means of lines $a\,g_1$, $a\,g_2$, $a\,g_3$. These lines, it will be noticed, cut the edge $c\,g_4$ in points d_1, e_2, and f_3; in order to locate these points on the layout we make use of circles passing through them, namely $c\,c_4$, $d\,d_4$, $e\,e_4$, $f\,f_4$. As, at the commencement of the imaginary process of rolling, the cone is supposed to rest on the line $a\,b_4\,g_4$, the correct distances between these circles must be measured upon this line. The actual layout is shown at (c), Fig. 12, and it is made in the following manner: Draw a vertical line $a\,a_2$—a line in any other direction would, of course, answer the purpose, but when drawing with instruments it is best to make a center line either vertical or horizontal—and set off upon it the length of the side A $a\,g_4$, namely 16 inches. Then, with compasses, describe the arc $g_4\,a_2$; this arc, being the path of the

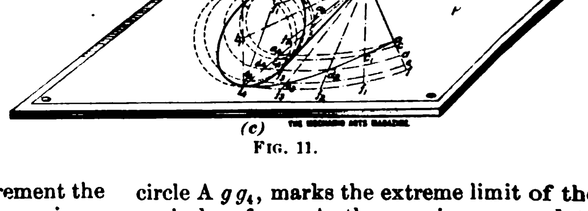


FIG. 11.

circle A $g\,g_4$, marks the extreme limit of the conical surface. As the cone is supposed to have made half a revolution by the time the point A g reaches the paper, the length P $g\,g_4$ must equal half the circumference of the circle A $g\,g_4$, or $\frac{16 \times 3.1416}{2} = 25.13$

inches; this length, then, must be measured along the arc $g_4 a_2$, thus locating the point P g; joining $a\ g$, we obtain the limiting edge. Now divide the arc P $g g_4$ into the same number of equal parts as at the beginning we divided the half circle $g g_4$ in view (b), and join a with points P $g_1 g_2 g_3$ by means of straight lines, as shown; these lines correspond with lines similarly named in view (b). We now proceed to construct the paths of the circles A $b b_4$, $c c_4$, etc. It is evident from what has already been demonstrated that these circles will all roll along circular paths around the point a in (c), so that it is only necessary to draw circular arcs of the proper radii with point a as center. The circle A $b b_4$ will roll along a circular arc of 4 inches radius, which arc, therefore, in (c), outlines the upper edge P $b b_4$. The other radii may be taken direct from view (b), and thus the arcs P $c c_4$, $d d_4$, $e e_4$, $f f_4$, in view (c), obtained.

We have now done all that is necessary to enable us to outline one-half of the lamp-shade layout; thus, point A c, being located in line A $a\ g$, and also upon the circle A $c c_4$ [see view (b)], must lie on corresponding lines in view (c), and must therefore be the point where these lines intersect, namely P c; point A d_1 in (a) is on the circle $d d_4$ where it is intersected by the line $a g_1$; therefore, on the layout it is the point of intersection of the corresponding circular arc $d d_4$ and the line $a g_1$, in other words, at d_1; in a similar manner, the two remaining points e_2 and f_3 are located. The curved line passing through these points, namely the line $c d_1 e_2 f_3 g_4$, completes the layout of one-half of the shade, and when this is repeated on the other side of the center line $a a_2$, the complete layout has been made.

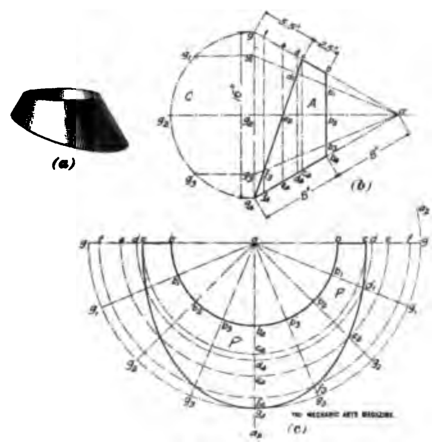


FIG. 12.

Other examples might be given, to show that the principles laid down in the first part of this article are applicable in a general way, but enough has perhaps been said to prove that the man who thoroughly grasps the idea of unrolling the surface to be developed is in a position to make any ordinary workshop layout; a little knowledge of geometry is, of course, necessary, but this can be readily acquired.

WATER SUPPLY, AND ARTESIAN WELLS.

Alex. T. Gibson.

THE ARTESIAN WELL AS A SOURCE OF WHOLESOME WATER SUPPLY—HOW IT IS DRILLED AND LINED WITH STEEL PIPE—THE MACHINERY AND TOOLS EMPLOYED.

IT IS a well-known fact that Nature does not furnish us with pure water. The pure article can be obtained only by distillation. But distilled water is absolutely unknown to most people, and would not be relished even if generally supplied, for the reason that the constant use of water containing iron, lime, and other minerals, as well as vegetable and animal matter, in suspension and solution, has so accustomed our palates to the taste of ordinary impure drinking water that, in comparison, the pure water would seem flat and insipid.

It is perhaps hardly necessary to state that no water can be purer than the source from which it flows, and that there is a vast difference between the clear cold spring or Artesian-well water and the discolored liquid, *called* water, that is either pumped, or falls by gravity, from some lake or stream —itself in many cases the trunk line for the sewage of cities and villages thereon, and

heavily charged with animal and vegetable matter and germs of all kinds; or, what is little better, and often worse, water from dug or shallow wells or water holes—worse, because such water is stagnant and therefore not as well aerated as that which flows from lake or stream. Either kind, however, is apt to be warm in summer—unless ice, which is generally impure, is used to cool it—and discolored at all times—unless filtered, which seldom removes the harmful impurities.

The subject of water supply is so broad and far reaching, and so vitally affects everything and every condition on this planet, that it can be classed with, or at any rate ranked as next in importance to, the sun and the atmosphere; and it would be possible to write volumes upon it. But our friend the editor draws the line at a few thousand words and also asks that this article be confined to one branch of the subject—namely, the Artesian well. Even this branch, however, if treated in detail, would fill The Mechanic Arts Magazine several times over, so we will endeavor to be as concise as possible.

The Artesian well, which derives its name from the province of Artois, in France, was used in both Mexico and China, centuries ago; indeed, it is known that the Aztecs of Mexico devised systems of water supply that in some respects rival any now in existence.

Some Artesian wells *flow*, that is, deliver the water to and above the surface, while others deliver to within a few feet of the surface; but all, when properly made, furnish a good supply of far better water than the majority of mankind is familiar with, and effectually shut off all surface water. A study of the death rate statistics of the large cities of this or any other land discovers a large proportion of deaths directly traceable to the drinking of water that is unfit for either man or live stock, even though it *is* drawn from a nickelplated faucet, and even though it is filtered and iced before being drunk.

The appearance and taste of water tell us very little about it; so we have to trust to the good faith of the great water companies. There will, we hope, come a time when the golden rule will prevail, when we shall cease to "do" others because we fear they are endeavoring to "do" us, when every man will understand the laws of health, and when every American citizen will think for himself, vote for himself, be intelligent, healthy, and free, and cease to be in any way a slave. Then, and not until then, will we get cheap and good water, and every other good thing we need.

The drilled hole which constitutes the Artesian well is the same, and is made with practically the same machinery and tools, whether it is drilled for water, oil, or mineral, or merely as a test hole for the foundation of a building. The only real difference is in the size and strength of the outfit, or "rig," as the well-contractor's plant is called. At the present time a test hole is being drilled in Pittsburg, Pa., which is to be 10,000 feet deep. Do you realize what that means? For a distance of nearly two miles a hole is to be driven through earth and rock! Think of the temperature that workmen would have to endure, and the cost and trouble of making such a hole by ordinary digging and blasting!

There are many first-class Artesian wells that are only from 25 to 75 feet deep; for many parts of this country 50 to 60 feet would be a very fair average. Such wells are completed in from 1 to 10 days, and cost from $25 to $200, according to the formation to be drilled through. A fair average cost for wells to supply from 100 to 500 people would be from $100 to $150. Think of going on from year to year paying the water rent you do, when your whole neighborhood, farm, or factory could be supplied free—once the small first cost of the well itself is paid for—with nature's best and purest brew. Or, if you are a farmer or live in an out-of-the-way village, think of the unnecessary suffering and loss the lack of a plentiful water supply costs you yearly.

This good water—not surface water—is to be found at a depth of probably less than 100 feet below the surface of your land. "Yes," I hear some of you say, "but we will have to pump it!" Did you ever get something for nothing? You want water on the upper floors of your buildings. Right you are. An up-to-date man should have modern conveniences; we improve by adopting improvements. The water company you now patronize has either to pump the water for you, or to locate its reservoirs at such an elevation—often several miles from the center of distribution—that the "head," or pressure, obtained is sufficient to raise the water the desired height. But the men who constitute the water company are not in business for their health alone, nor from any personal interest in *your* health, and, considering the quality of the water they supply, they make you pay more than your share of the cost of constructing and

maintaining the pumping plant or reservoirs and pipe lines. Why not get back to first principles and do for yourself—by means of the Artesian well—what you have hitherto been hiring some one else to do for you? You can do it both better and more cheaply. And if, after you personally, or together with your neighbors, have had an Artesian well drilled, it does not deliver the water high enough for you, put up a windmill to do the pumping; or, if you prefer it, use a gasoline engine or any one of the several pumping engines that are to be found on the market.

Some one asks, "Will the water always be cold and soft?" For average depths, the temperature the year round will be about 45° Fahrenheit, and you will save the ice bill, and be saved from the ice impurities. If you are a farmer, packer, brewer, hotel owner, shipper of milk, or a member of any one of the many trades where good cool water is an essential, this point alone will pay you hundreds of dollars yearly. As to softness, if it does not come from lime or similar rock, it will be as soft as you could wish. Comparatively few Artesian wells are hard; but, if you live in a limestone country, most of the water you get will be hard, no matter what source of supply you may use.

FIG. 1.

In many parts of the world, flowing wells are sure at depths of from 50 to 500 feet. In other sections, Artesian wells that flow over the top with any great pressure are rare, though nearly all sections have some examples. But a good supply that will rise to within a reasonable distance of the top is now an assured fact the world over.

If you have an old dug well that goes dry at times or furnishes a poor supply of poor water, have a 6-inch iron pipe put in the bottom, and drill down until you shut off the surface water and get a supply that is fit to drink. Most dry wells are simply catch-basins for surface water and other impurities, including rats, cats, and so forth. A few dollars paid to the chemist for an analysis of your water supply will be well invested and may save the time and expense of a funeral.

Many Artesian wells are in use today on the Sahara desert.

Oil and gas wells are from 500 to 4,000 feet deep, and cost from $3 to $10 per foot. There is an Artesian well in Seneca County, N. Y., that flows 1,000,000 gallons of water a day. Several in Dakota and other sections flow 4-inch to 8-inch streams with a surface pressure of 150 pounds per square inch, and furnish power to electric-light and power stations, etc., and the water is used for culinary purposes and also for irrigation.

In one town in Idaho, hot Artesian water is piped through the streets and used for warming the buildings. There is a well in California so capped that the water flows from it in the form of an umbrella 40 feet in diameter. The writer was present at the drilling of a well in Fifth Avenue, New York City, that cuts through 2,400 feet of solid rock, and supplies 700 people with water for all purposes. In our new territory, the Hawaiian Islands, irrigation by Artesian wells is now quite common, and in the

borough of Brooklyn, N. Y., more than 1,000,000 people are supplied with a total of 50,000,000 gallons a day from Artesian wells. Many small cities and villages have water works that are supplied exclusively by Artesian wells. California has over 2,500 flowing wells, each of which irrigates on an average 1 square mile of land, or 640 acres. In the same state there is one man who owns 42 such wells. He bought desert land for $1 an acre, drilled wells, planted oranges, raisins, and other fruit, irrigated the land, and now sells it at from $200 to $500 per acre. Did it ever before occur to you what a blessing the Artesian well is to humanity?

The Mormon Church, in Utah, have over 2,000 of these wells, 700 of which flow. In Nevada, at altitudes of from 6,000 to 10,000 feet above the sea, there are 67 wells, each of which flows from 60,000 to 100,000 gallons daily. New York City has hundreds of them, and it is estimated that they save $1,000,000 in water rents yearly.

While the Artesian well, in its crude form, was made centuries ago, it is only during the past twenty-five years that, by reason of improvements in the manufacture of iron and steel pipes and machinery, it has become a prominent factor in the civilization of the world. The first oil well in the United States was drilled in 1859 near Titusville, Pa., by Colonel E. S. Drake. Since then, well drilling and the manufacture of machinery and pipe for it has been a large and growing industry.

FIG. 2.

Those who have never made a study of geology can learn much from a practical study of Artesian well-drilling, and not only about water supply, but about other riches that Nature has in store under our feet—riches that man by his skill and intelligence is so rapidly developing.

Regarding the manner of drilling, and the machinery and tools used in the production of the Artesian well, something will now be said. In most parts of the world there are from a few feet to several thousand feet of earth on top of the various strata of rock. This earth also lies in layers, or strata, of varying thicknesses. Many of the best wells find their supply in water gravel; others find theirs in rock. The drilling machine, as shown in Fig. 1, is placed over the spot where the well will be most convenient. It will be readily understood that drilling a hole through, it may be, several thousand feet of earth and rock is a very different thing from drilling through a piece of wood or iron. In the latter case the drill

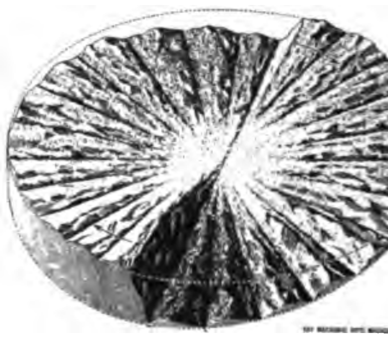


FIG. 3.

is caused to rotate and the wood or metal is removed by a sharp cutting edge. In drilling into the earth the form of the tool and the manner in which it is operated depend largely upon the formation to be drilled through; but for artesian wells the *percussive* method is almost invariably employed. In this, the drilling tool, or bit, hangs from a hawser-laid rope 1 inch to 2 inches in diameter (see Fig. 2) and is alternately raised and let fall, so as to strike a series of sharp blows, and the hole drilled is lined with steel or iron pipe. To cause the flat bit (see Fig. 5) to drill a round hole, the rope is twisted from right to left and from left to right, a dozen or more turns each way; as it gradually untwists, it rotates the bit step by step, so that the bottom of the hole, while drilling is in progress, is somewhat as shown in Fig. 3, in which the direction of rotation is indicated by the arrows *d* and *e*. To hold the bit, to help guide it, to add to the force of its blows, and to release it when from any cause it gets stuck in the hole, there are strung above it certain tools which, with the bit, are known as the "string"; this consists of rope socket, jars, sinker bar, and bit, put together in the order named. In Fig. 4 is shown a good form of *rope socket*, by which the rope is very securely gripped; in another kind the rope is held by rivets passing through it. The *jars* are shown in Fig. 6; they are not usually put on until rock is reached; their duty is to prevent loss of the tools when from any cause they become wedged in the hole; the two parts, *a* and *b* in the figure,

are linked together like the links of a chain; if the bit becomes jammed, a few inches of rope are let off the reel, causing the jars to hang loose; when the engine is started, the two parts come together with a "jar," hence the name of the tool, and quickly free the bit. Sometimes a loose piece of rock will fall in from the side of the hole, and thus wedge the tools; or, a newly-dressed bit—slightly larger than the worn one it replaced—gets jammed; the jars will then free the tools where a steady pull would often completely fail. This points to the advisability of not using a bit too long. The sinker bar (see Fig. 7) is added for holes that are more than a few hundred feet deep, the additional weight being then necessary because the very long column of water through which the tools have to drop retards their speed and reduces the force of the blows. Every so often, as drilling progresses, it is necessary to clean out the hole; for this purpose the sand pump (see Fig. 8) is used. The string of tools being hauled out, the pump is lowered until it strikes the bottom of the hole; in the act of striking, the pipe falls around the projecting end and raises the valve, and some drillings enter the pipe; this operation is repeated by simply lifting and dropping the pump until full, when it is taken out and emptied; on its way out of the well, the weight of the contents keeps the valve closed; when it reaches the top, a man detaches it and carries it to a convenient place for emptying, where he sets it on end—valve down—and allows the weight of the pipe to open the valve and the contents to discharge themselves.

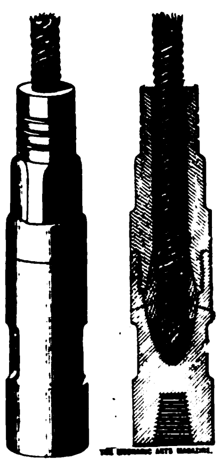


FIG. 4.

By means of alternate drilling, driving, and sand pumping, length after length of pipe is forced into the earth, until the required amount and quality of water is found, or until bed rock is reached. The pipe used is from 4 inches to 24 inches in diameter—6-inch being the best size for ordinary water wells. This pipe, either of iron or steel, is made in 18- to 20-foot lengths. The several lengths are screwed together as they are driven into the earth. It is made in various weights, the manufacturers furnishing whatever weight is ordered; 6-inch pipe weighs from 10 to 30 pounds a foot, according to its thickness.

Water is poured into the pipe as drilling and

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

driving progress, and the drill, which weighs from 300 to 4,000 pounds, is raised by the engine, and allowed to drop, 30 to 80 times a minute. The drill crushes and grinds earth and rock into powder, of which the water makes mud and slush, which is periodically pumped out by the sand pump, as already fully described. As the hole is deepened, more pipe is screwed on and driven, either by a driving maul weighing several hundred pounds or by the string of tools. If the latter method is adopted, the tools are let down into the pipe for a few feet, and a clamp screwed to them so as to strike on a drive cap on top of the pipe; as the tools are very heavy, and are raised and dropped many times a minute, they drive the pipe very rapidly, sometimes at the rate of from 25 to 100 feet a day, depending on the formation driven through.

There is a heavy steel shoe on the bottom length of pipe to prevent stones and boulders from crushing it in. Sometimes the drill works ahead of the pipe and makes a hole for it to follow in—that is, if the formation will stand up; at other times the pipe is driven first and afterwards drilled out; the driller must use his judgment about this and many other matters.

If satisfactory water is not found before

rock is reached, the pipe is driven hard to make a tight joint with the rock and thus shut off surface water, and the drilling is continued in the rock, and no more pipe used, the rock forming the wall of the well, if the latter is not more than a few hundred feet deep. The water thus obtained is from the veins or seams in the rock.

Each driller carries with him a complete blacksmith outfit, and he usually has plenty of use for it. The string of tools is from 15 to 50 feet long, and weighs, as already mentioned, from 300 to 4,000 pounds; the various tools are screwed together so well that it is very seldom they come unscrewed in the hole.

When a bit wears, say, $\frac{1}{16}$ to $\frac{1}{8}$ of an inch smaller, the tools are drawn out of the well by the engine, and the bit is unscrewed by heavy tool wrenches that weigh from 50 to several hundred pounds each; another bit, which, while the drilling has been going on, the blacksmith has dressed to full size and proper shape, is put on, the hole sand-pumped, the tools lowered back into position, and the drilling continued. The hole should be kept as nearly as possible the same diameter from top to bottom, and perfectly straight and plumb.

When the proper quality and quantity of water is found, the well is tested by means of the sand pump or by a power or steam pump or ejector; then, if all is satisfactory, it only remains to place the necessary pumping apparatus, that is, in case the well does not flow.

The speed of drilling varies from a few inches to sometimes 50 or more feet a day, according to the nature and hardness of the formation.

In conclusion, it is only just to say that for the illustrations accompanying this article the writer is indebted to the Keystone Driller Co., Beaver Falls, Pa., who are probably the best known manufacturers of well machinery. To any one who wishes to more fully investigate this subject, the company would no doubt send their catalogue, which contains some important as well as interesting details.

SUBMARINE MINES.

Ernest K. Roden.

WHY THE SUBMARINE MINE IS A NECESSITY IN MODERN NAVAL WARFARE—CONSTRUCTION AND OPERATION OF MINES—THE CAMERA OBSCURA AS AN OBSERVATION TOWER.

BEFORE the days of steam power, when a warship attacking a fort was more or less at the mercy of winds and currents, experience proved that one gun ashore was more effective than many afloat. But the introduction of the screw propeller, followed later by that of armor-plating and big guns mounted on speedy vessels, wrought great and radical changes in this direction, for it left a hostile fleet free, under cover of darkness or fog, to move swiftly past shore batteries, and anchor securely in positions from where their fire could destroy the adjacent city or compel the payment of an enormous ransom. Furthermore, the enemy's ships—under better control, less vulnerable, and possessed of much higher speed than formerly—were to be encountered by guns more unwieldy and, in most of the harbors, due to the naturally contracted sites available for shore batteries, much smaller in numbers than those afloat. The defense thus found itself at a great disadvantage, and as a consequence the attention of military engineers was urgently directed to the devising of some means of holding the enemy under fire and depriving him of the comparative immunity resulting from high speed, and so restoring to the defense its lost superiority.

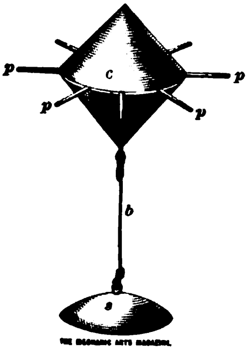


FIG. 1.

This vitally important object has been accomplished by the modern submarine mine, the destructive power of which has made it an essential auxiliary of the land gun. In a judicious system of harbor defense these mines are indeed indispensable, for, while the guns are necessary to develop

the full power of the mines, the latter are no less essential as a protection for the guns. Thus, submarine mines are invariably defended by heavy guns placed in batteries secure against landing parties; otherwise, the enemy's small boats could creep for them or else clear a passage through them by exploding so-called countermines.

Submarine mines were extensively used by the Confederates during the Civil War, and Germany made good use of them during the Franco-Prussian war in keeping the French fleet from bombarding her ports. Since those times, however, and especially recently, great improvements have been made in the mechanisms employed, and the introduction of high explosives, such as dynamite and guncotton, instead of gunpowder, has immensely increased their power and destructive range.

The simplest form of mine is represented in Fig. 1; this is the *contact mine*. It consists mainly of an iron case *c* which is connected by a cable *b* to the sinker *s*, the latter being of sufficient weight to hold the mine in place. The case *c*, in which the explosive charge is stored, is provided with a number of projecting points *p*, each of which is armed with a firing pin. If any one of these firing pins is struck by a passing vessel, it will be driven in, exploding a percussion cap and causing the charge to burst. The distance below the surface of the water at which the mine is suspended must be so arranged that it is not too near the surface when the tide is low, nor at too great a depth when the tide is high. An immersion of at least 8 feet is necessary to cause the charge to explode with sufficient force to destroy a modern battle-ship; hence this should be the depth of the mine at low water. If the difference between high tide and low tide is very great, it may not be possible to make the contact mine effective for all conditions; this is a defect, to remedy which numerous devices have been suggested, the main idea being to automatically increase or diminish the length of the attached cable as the tide rises and falls, thus keeping the mine at a constant distance below the surface.

FIG. 2.—EXPLOSION OF A GROUND MINE. *From Photograph.*

In its simple form, the contact mine is dangerous to friend as well as to foe, and, if it gets adrift, it may sink a harmless merchant ship; the only reasons for its use, then, are its simplicity and the fact that it can be improvised at short notice. It is evident that the efficiency of this mine will be greatly reduced by a strong current, for it may be forced down so far as to be rendered useless. Where the currents are rapid, therefore, and in narrow channels, these mines are usually placed on the bottom, and are then called *ground* mines—a class which we will describe later.

Nowadays, electricity is the chief igniting agent used in submarine warfare, because it enables the obstructed channels to be safely traversed by friendly vessels. The electro-contact mine is constructed on the same general principles as the contact mine, but some of the weaknesses of the latter are absent. When one of the firing pins is driven in, instead of exploding a percussion cap, it simply closes a break in an electric circuit that passes through the charge, and this does not necessarily explode the charge, for the following reason: There is an electric cable leading from the charge to the sinker, or anchor, and thence to a station on shore; at this station there is another break in the circuit, and, unless this latter break has previously been closed, the driving in of the firing pin will not explode the mine. Herein is an element of safety to friendly ships. When no enemy is in sight, and friendly ships are passing in and out, the break at

the shore station is left open, so that if a mine is struck it will not explode. Thus, a vessel chased by an enemy's cruiser could pass over the mines with absolute safety, while to the pursuer they would at once become deadly engines of destruction. In these mines the firing pins are fitted with springs, which cause them to return to their proper positions in case they are accidentally

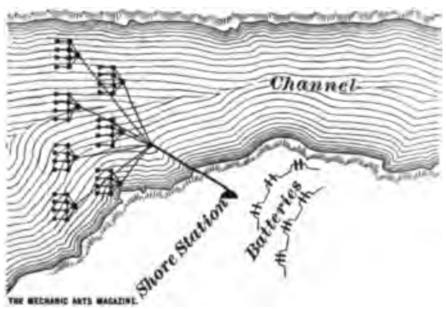


FIG. 3.

driven in. In addition to this ingenious contrivance, many devices have been invented and adopted which add to the efficiency of the mines, and most of them are perfect little marvels of ingenuity and delicate mechanism.

But there is an improvement on both the contact and the electro-contact mines, which is now used whenever the conditions make it possible. This is the *observation* mine. Here, the mine and the firing mechanism are in separate cases; there is a contact buoy containing the firing pins, which is placed a few feet below the surface of the water and connected by a cable to the mine itself, which is several feet below the buoy, the whole being attached to an anchor. An electric cable connects the mine with the shore station and there are, for each mine, two distinct and separate electric circuits, one for signaling and the other for firing. Whenever a firing pin of the contact buoy is touched, the signaling circuit is closed, and this either rings a bell or displays an electric light at the shore station. Under each bell or signal light, whichever it may be, is a key for closing the corresponding firing circuit.

When one of the bells rings, the observer at the keyboard in the shore station knows that the buoy above the corresponding mine has been struck, and he immediately touches the key below that bell and thus closes the firing circuit and causes the mine to explode. The shore station should be underground, and large enough to allow the operator to be comfortably seated within easy reach of the firing battery and key. If possible, the station should be hidden from view with bushes or whatever vegetation may grow around; if in barren ground, the roof should be painted as nearly as possible the same color as the surrounding soil. These precautions are very important, since a single well-aimed shell from an enemy that discovers the station will render a whole mine field useless.

Observation mines are usually placed in groups of from four to seven, as shown in Fig. 3. The groups are placed in two or more lines, so that a ship which happens to pass *between* the groups of one line will surely pass *over* the mines in the next line; and the mines are anchored at a sufficient distance apart to prevent the shock from the explosion of one from causing the adjoining mine to explode.

When the depth of water is considerable, or the current very swift, the mines hitherto described cannot be used, and the ground mine is resorted to. This mine simply rests on the bottom, and must be quite heavy; and the greater the depth of the water, the greater amount of explosives will have to be used. For instance, a depth of 65 feet will call for a charge of 1,200 pounds of guncotton—equivalent in explosive power to about 4,800 pounds of ordinary powder.

The method of firing a ground mine is very simple and ingenious. Two observers are usually employed to determine when the hostile ship is directly over the mine. The

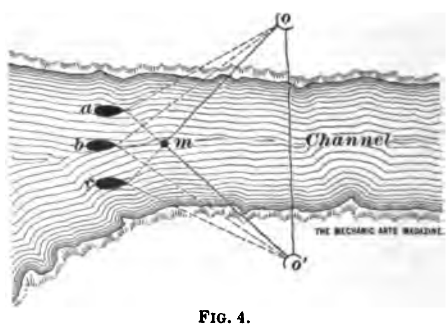


FIG. 4.

two shore stations, *o* and *o′* in Fig. 4, and the mine *m* are all in the same electrical circuit, being connected by a cable in which are two circuit breaks, one at each station. These two breaks must be closed simultaneously, or the mine will not explode. Each observer has a telescope fixed on a vertical pivot which permits it to swing toward any point on the horizon, and each telescope is so arranged that when

pointing directly towards the mine the break at the electrical circuit at that station will be closed. The observers, therefore, simply keep their telescopes pointing toward the advancing ship; then, if the enemy passes over the mine, both telescopes will at the same instant be pointing toward him and also toward the mine; this will cause both breaks in the firing circuits to be simultaneously closed, and the mine will explode under the ship. This would be the case with the ship at *b* in Fig. 4, provided she keeps her course, while the ships at *a* and *c* will not pass over the mine. With ships *a* and *c*, then, the two circuit breaks will never be closed at the same time, and the mine will not be exploded. This very simple but ingenious system prevents a valuable ground mine from being needlessly exploded.

During the defense of Venice in 1859, ground mines exclusively were used. The Austrians, who at the time had possession of the city, decided to plant mines in the harbor and in the channel leading to it, to prevent the Italian fleet from entering; their method of exploding the mines is illustrated in Fig. 5. A camera obscura was placed at a convenient spot overlooking the harbor, in such a position that the mirror *m* reflected the view through the lens *e e′* upon a large white table *T*; in this manner every movement of any vessel in the harbor was rendered plainly visible to the officer within.

The mines were now sunk, while an observer in the camera tower made a pencil mark, indicating upon the table the exact location of each mine, and in addition put down the number corresponding to it. This complied with, a boat was rowed in a circle around the spot where each mine had disappeared, to indicate its zone of destructiveness, and the man in the tower, watching the moving image of the boat, traced a corresponding little circle upon the table. In this manner a picture, or map, of the harbor was obtained, upon which were small numbered circles indicating the location and number of each mine. Inside the tower and within easy reach of the observer were electrical wires leading to the several mines. During an attack, the duty of the observer was to watch the approaching fleet as reflected on the camera table, and, as soon as he saw a vessel come within one of the little circles, to at once explode the corresponding mine by closing the circuit in the wire leading to it. Of course, this optical system could be used in the daytime only, unless at night the harbor was well illuminated with electric light.

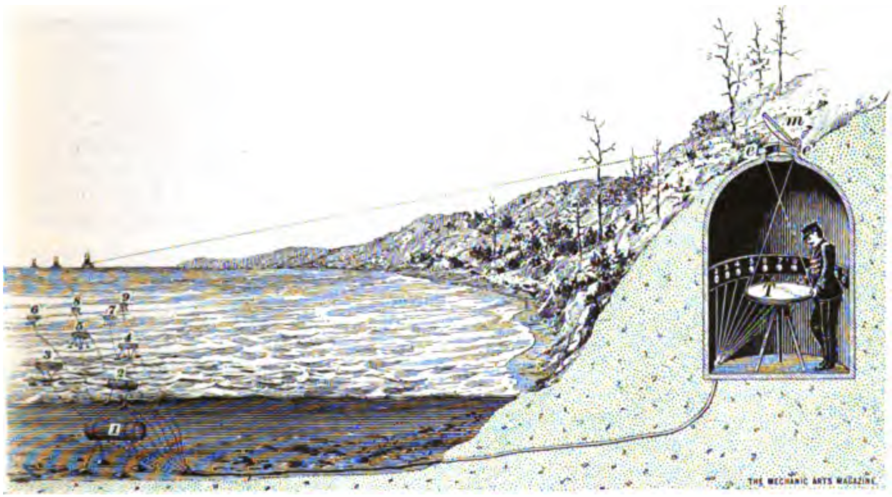


FIG. 5.

In many forts that guard the entrance to a harbor, the guns are mounted in such a manner that they cannot be trained upon the inner harbor, so that a ship that has succeeded in penetrating to this inner harbor would be practically free to use her guns, and cause what damage she wished upon the rear and flanks of the forts. Such harbors are generally supplied with ground mines containing enormous charges of explosives, for the purpose of reducing the intruder to fragments.

The explosives now most commonly used in submarine mines are guncotton, dynamite, and explosive gelatine. These are superior to gunpowder, not only because their destructive power is, weight for weight, from four to six times as great, but because they are not seriously affected by moisture; in other words, a leak in the case containing the charge will not render it useless, as it would if gunpowder were used. The pressure necessary to blow a hole through the bottom of a modern battle-ship has been estimated to be from 6,000 to 10,000 pounds per square inch.

To find the approximate distance at which a given charge of high explosive will be fatal to a ship's bottom, the rough rule is to divide the weight of the charge in pounds by 10; this gives the distance in feet at which the charge will destroy a double bottom—supposing the charge to be well immersed. Thus, 500 pounds of, say, explosive gelatine would prove fatal at a distance of about 50 feet. In practice, however, this distance is considered the maximum, and a less range is expected.

Even where the explosion of the mine fails to blow a hole through the ship's bottom, the shock may cause serious damage by throwing delicate machinery out of action, injuring electrical appliances, or stopping the ship's engines, thus placing her in a position of much danger. Again, the tremendous concussion may cause the detonation of high explosives within the ship, resulting in her complete destruction.

It is an interesting fact that every explosive is most sensitive to one particular kind of shock or vibration; that is to say, a shock or vibration that will cause the explosion of one charge will not necessarily cause the explosion of any other; but if that explosive is subjected to that shock—even though comparatively light—it will be very liable to explode. It is therefore of paramount importance, on board a man-o'-war, to store the high explosives where they will be free from shocks or violent vibrations; and it is equally important that the defenders cause such violent vibrations as to render the invader harmless.

In connection with the history of submarine mines, there are many records of bravery and heroism. During the Civil War, the Confederates were particularly clever in the use of mines for obstructing channels and rivers; and during the struggle no less than twenty-five ships of war fell prey to them, in addition to the many that were more or less injured by them. How Admiral Porter took his squadron safely through a field of mines by the adoption of a clever ruse is a matter of history so well known as to need but passing mention. The admiral well knew that the river was "planted," but the exact location of the mines he, of course, did not know. So he built a dummy monitor, of wood, taking great pains to make it look as much like a real monitor as possible. This done, he ordered the whole squadron to advance in single column, with the dummy at its head. As soon as the improvised craft reached the mines, the latter were exploded and the dummy blown to pieces, while the rest of the squadron passed on without the least injury.

In our recent war with Spain, Admiral Dewey, in command of the Asiatic squadron of the United States Navy, made himself famous by running over a mine field and attacking the Spanish warships at their anchorage in Manila Bay. Truly this was a risky undertaking, to enter a comparatively unknown harbor that he knew to be planted with mines, and it proved the admiral's fighting quality; for, however brave a man may be, he may be excused for thinking twice before engaging with an enemy that he cannot see. Sailors have a great and natural respect for submarine mines, and usually give them as wide a berth as possible. At Manila, judging by the mines that were exploded in the wake of the squadron, Dewey evidently caught the Spanish operators "napping" at their shore stations, and in this no one will deny that he was fortunate.

STEPPING STONES IN THE ART OF COOKING.

Mrs. Henry Esmond.

Step III: Frying; Choice of Fat; Preparation of the Food Materials.

FRYING, of which there are two distinct kinds, is cooking in hot fat. There is *deep-fat* frying, the name of which explains itself, and *sautéing*, or frying in a small quantity of fat in a shallow pan. For more than one good reason, people would be wiser if they did not eat fried food at all. In the first place, it is very indigestible; in the second place, it fills the kitchen with a most disagreeable odor—the smell of smoking fat—and if the house is a small one the smell will find its way into the living rooms, and is of such a penetrating kind that it is very difficult to get rid of. For this second reason, then, people who live in small houses should eat fried foods as little as possible, and if the mistress of the house does her own cooking she should put on the oldest cotton dress she possesses, and tie her hair up in a thick cloth, so as to exclude the fumes of the smoking fat. What is more unpleasant than to enter a house that smells of the frying pan, to be greeted by a lady whose hair and clothing is redolent of smoking fat! The fact that fried food is indigestible will, we fear, never stop an American from eating it, and, as food properly fried is much less indigestible than food badly fried, there is good reason why the housewife should know what there is to know about the art of doing it well.

We will begin with deep-fat frying. Many people imagine that the fat in the frying pan boils, because, when hot enough to cook in, it bubbles. This is a mistake; fat does not boil until it reaches a temperature of between 550° and 600° Fahrenheit; whereas the proper temperature to do frying in is about 385°. It is true that at the latter temperature the fat bubbles, but this is caused by the water in it evaporating.

When a food material is immersed in hot fat, the result is similar to that explained in previous articles in connection with boiling and roasting—the albumen on the outside is hardened, and thus the juices in the food are retained. The secret of successful deep-fat frying is to have the fat hot, and to have plenty of it.

Articles to be fried should first be dried, then dusted over with flour. This prevents any water that the food contains from escaping into and lowering the temperature of the fat, in which event the food will soak up the fat and become not only very greasy and unpalatable but also exceedingly unwholesome.

Fish, meat, croquettes, and fish balls should be rolled in either flour or bread crumbs, then in egg, and again in the bread crumbs; when plunged into the fat, the albumen in the egg immediately hardens, and, with the crumbs, forms a crust that effectually prevents the fat from soaking in.

A mixture of pure lard and beef-suet dripping is very good for frying purposes, but the lard alone is preferable. Suet from lamb or mutton should not be used, as it has a very strong taste and odor. Olive oil is best, but as this is very expensive it is rarely used. A product of the cotton seed, called *cottolene*, is much used down South, and, if fresh, is very good, though many people object to it because of its peculiar odor.

An iron kettle with a good lip or spout for pouring is best to heat the fat in. Put about 2 pounds of fat into this kettle, and let it heat until it smokes. Then test the heat by dropping in a small piece of bread; if it browns while you count 30 seconds, the fat is hot enough to cook raw potatoes, doughnuts, fritters, etc. For cooking croquettes, fish balls, or anything made of food that has been cooked before, the fat must be hotter; for these the bread must brown in 20 seconds.

The articles to be fried should be placed in a frying basket—a wire basket made specially for the purpose. Never drop the articles into the fat singly, as it is then impossible to get them all out at the right time; and do not put too many in the basket at one time, or the fat will be cooled so much that instead of being cooked the food will soak up the fat and be spoiled. Have upon the stove, at your side, a large dripping pan with several sheets of unglazed paper in it, upon which to drain the food after cooking. Taking hold of the handle, plunge the basket into the hot fat—letting it become entirely immersed—and keep it there until the

articles are done; then, raising the basket, hold it over the kettle until the adhering fat has dripped off; then empty into the dripping pan. Do not allow the separate articles to touch one another while on the paper, and you will find that much of the fat remaining on them is absorbed.

Before the fat is put away, after use, it should be clarified. Take a large potato and cut it into slices about half an inch thick, and, after the fat has cooled a very little, drop them into it and set aside where it will not be disturbed until quite cool; then, before it has begun to solidify, pour off into a crock or pail kept for the purpose, and it will be found that all the particles of food, flour, crumbs, etc. that had escaped into the fat have settled to the bottom with the potato chips. This fat can be used many times if care is taken in the clarifying of it.

In sautéing, a very small quantity of fat is used—enough merely to well cover the bottom of the pan. Hash, fish steaks, potatoes, small steaks of veal or pork, omelets, eggs, etc. should be sautéed. The pan should be heated, and a heaping tablespoonful of fat melted in it; then the food material, after being prepared as already described in connection with deep-fat frying, put in and quickly browned, first on one side, then on the other. Cakes of all kinds that are cooked on the griddle are, in reality, fried, though no more fat is used than is needed to prevent them from sticking to the griddle.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

Transformed Africa.—Part II.

THE study of the history of any country will show that its development is closely connected with its natural physical conditions, its position, and its configuration—in short, with its geography. And a glance at the geography of Africa, as revealed by modern explorers, explains the surprising fact that the interior of this great continent, lying in the pathway of ocean travel and within sight of Europe, should have remained a sealed book until the nineteenth century had left youth behind. Egypt, it is true, was in the forefront of ancient civilization, and northern Africa shared in the vicissitudes of early European history as a part of the European system, washed as it is by the waters of the Mediterranean, the "Great Sea," once the highway of commerce for the civilized world. But Egypt is only a narrow belt, intersected by the Nile; and northern Africa was cut off, as it is today, for all practical purposes, from the rest of the continent by the impassable barrier of the Sahara.

Elsewhere than in the north, African geography is peculiar, and of a character calculated to discourage the explorer who seeks new lands for settlement by civilized men. It is estimated that a full half of the continent is occupied by deserts, and by infertile lands approximating to the desert character. Around the coasts, where good harbors are few and far between, lies a belt of lowland from 100 to 300 miles in width, where malarial fevers of all kinds prevail; in some parts the white man is a sure prey to tropical disease. From this low belt the land rises steeply in a succession of terraces to the central plateau, which in the south and east attains a great elevation; far less than that of central Asia, but quite high enough to be a hindrance to the migration of newcomers, which naturally follows the lines of least resistance. In most regions of the world the rivers form natural highways by which a country can be entered and explored; but African rivers are rendered impassable by rapids as they descend from the elevated plateau to the lowlands of the coast. What wonder, then, that the traveler who found himself barred from access to the interior, turned his back on Africa and sought more hospitable lands?

The configuration of Africa is thus the key to its history; for the inaccessibility of its highlands and its unhealthy coast, combined with its tropical situation, have contributed to the late settlement of European colonists. But these obstacles are no longer effectual hindrances; and under the impetus of a need for colonial expansion on the one hand, and of political rivalry on the other, European influences have now taken firm root.

Our maps show that seven European powers have claimed a share in Africa; but,

for the present, little interest attaches to five of these. Germany's occupation is very recent, and has been attended by no striking incidents; while Spain and Italy, in their small coastal territories, chiefly lowland, are inert and unprogressive. Portugal has a long coast line, but she has neither the wealth nor (apparently) the energy necessary for the development of the healthier "hinterland" in which colonies might be planted—notwithstanding the hopeful and ambitious utterances of her statesmen respecting the future. Her ports of Beira and Delagoa Bay on the east coast are mainly used by foreign nations for their own commercial purposes. The day may come when these countries will give a better account of their stewardship; if they fail to do this, their inheritance will probably be absorbed by those who prove themselves more capable administrators. The Kongo State, under Belgian control, occupies the fertile basin of the second largest river system in the world, once the bed of an inland sea. It is still in the initial stages of development, but steady progress may be expected, now that a railway has connected the coastal lowlands with the Kongo River above the rapids which render it unnavigable as it descends from the interior plateau to the Atlantic through a channel from four to eight miles in width. The future of the Kongo State may be great; but for the present the British and French possessions are of more general interest.

The sphere of Great Britain lies mainly in South and East Africa, and includes the greater portion of the subtropical lands which are favorably situated for European settlement. It is fortunate for Great Britain that her occupation began thus at the south, whence the natural line of expansion was along the elevated axis of the continent, whose general direction is northeast, towards the shores of the Red Sea. Commencing with a modest colony at the Cape of Good Hope, which was ceded by the Dutch in 1814, her boundaries gradually extended by ordinary processes of growth, including Natal and Zululand on the coast, and Bechuanaland on the north. As was suggested in a previous article, the sudden appearance of Germany on the stage of African affairs in 1884 hastened the apportionment of such parts of the continent as were not already under European influence, and Great Britain's African frontier was pushed rapidly forward. Although the great acquisition, known as Rhodesia or Charterland, has only recently come under her flag, a railway already penetrates many miles into the heart of the country, which five years ago was under the rule of barbarous tribes. Its boundaries skirt the western shores of Nyassa, one of the lakes which form so remarkable a feature of East Africa, and touch the southern point of the long, narrow Lake Tanganyika, on which navigation is free to all nations. Two hundred miles beyond the northern point of this lake, lies Uganda, a district of British East Africa, bordering on the great Victoria Nyanza, the source of the White Nile and second only to Lake Superior among inland fresh-water seas. Thence along the Nile the British power predominates without interruption through the Sudan, the scene of Lord Kitchener's recent overthrow of the Dervish forces, and through Egypt, which is virtually under a British protectorate. (See HOME STUDY MAGAZINE, December, 1898, page 526.)

A British railway "from Cairo to the

Cape" was regarded not long ago by sensible people as an extravagant fancy, conceived in the brain of an enthusiast. Large sections of such a railway, however, already exist in North and South Africa, and a space of only 500 miles in the center of the continent separates the British territories in which it can be constructed, when commercial necessities or the protection of the country demand it. The surface of this wide belt of land varies greatly. There are desert spaces in the south and west; infertile lands where cattle raising is the only profitable agricultural industry; mining districts awaiting development; the famous diamond fields of Kimberley; lowlands in river basins and on the coast, where the prolific soil breeds malarial disease; but the greater portion, south of the Sudan, is on a plateau of moderate elevation, sufficiently watered, where the climate permits white races to make a permanent home and produce the necessaries of life.

Quite different are the British settlements in West Africa. These lie in the basin of the river Niger, where the climate is tropical, and the elevation above the sea is comparatively low. This region has so often proved fatal to Europeans that it has earned the name of "the White Man's Grave." Yet here are officials, traders, and missionaries; and so important are the commercial possibilities of the country that Great Britain and France hold firmly to the shares which each has respectively acquired; and Germany has claimed and secured a section for future development.

The French sphere lies in the north of Africa, where, beyond the coastal region of Senegal, the fertile and populous basin of the upper Niger, and the province known as the French Kongo, her power predominates over two million square miles of—sand and desert. Algeria, on the Mediterranean coast, was won by forty years of fighting with Arab tribes, and has now an orderly government; but, notwithstanding the beauty and charm of the maritime portion, the desert character of the "hinterland" forbids profitable expansion. Nor, even were the country fitter for settlement by Europeans, are the French successful colonizers. Their brilliant imagination, enterprise, and courage fit them better for conquest than for commerce or colonization, as is demonstrated by the history of the past. They are enthusiastic explorers, and dream of future control of the northern half of the continent, from Senegal to the Red Sea, including the basin of Lake Chad at the south of the desert, and the upper part of the Nile valley. Suggestions have been made for moderating the climate of the waste region, and for promoting commerce by providing it with water communications. The Sahara was once the bed of a salt lake; and it is proposed to reopen the connections with the Mediterranean which Nature has gradually closed, and thus transform a part of the desert into an arm or inlet of the sea. This sounds chimerical; but what may not the twentieth century see? Meanwhile, with praiseworthy skill and industry, efforts are being made to redeem in part the desert barrenness; oases are cultivated, and are even created by boring for water which is generally found near the surface, by planting palm trees, and by encouraging vegetation. Yet France has no surplus population to provide for; and the most ardent colonizers could not settle in such a region of tropical heat and aridity. A few roving explorers, and the necessary military and civil officials, constitute the white population of the quarter of Africa over which the tricolor floats, except in the maritime provinces of Algeria and Tunis.

The degree of authority exercised over these vast European possessions differs as much as does the character of the soil. There are regularly organized colonies with representative governments; there are crown colonies, with a less degree of independence; there are chartered companies, which are in fact colonies in process of formation; there are protectorates; military posts; native states, and "spheres of influence"; and the administration of law and justice varies in each of these. In forming a judgment of their internal condition and management, they should not be compared with countries inhabited for generations by races with whom law and order are traditionary and hereditary, but with the state of things which existed in Africa fifty years ago. And it should be remembered that the whites are as yet but a small minority of the population, even in the older settlements. Rough and ready as the methods of administration may be in districts where white men are still pioneers, the standard of justice—as Christianity and civilization demand that it should be—is incomparably higher than the tyranny of force exercised by the native tribes when their power was unbroken. No less a result could justify the experiments which are now being tried on so large a scale and with such keen competition by European nations in Africa.

GOOD SCHEMES

GEAR-TOOTH LAYING OUT SCHEME.

Hurland Tuttle, Battle Creek, Mich.

THE FOLLOWING method of laying out tooth profiles, without employing the odontograph, is useful to draftsmen, but is intended especially for patternmakers, because they require—what they are generally without—the means of obtaining the theoretical profile

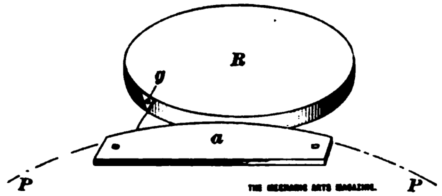


FIG. 1.

with accuracy. It is almost impossible to make an accurate layout by means of intersecting lines as used in the drafting room, but, by applying the simple principles on which the tooth outlines are based, great accuracy can be obtained.

Taking, first, the cycloidal teeth, we all know that the profile consists of two curves —the face and the flank—the first of which is the path of a point in a circle rolling on the *outside* of the pitch line of the gear, and the second the path of a point in the same circle while rolling on the *inside* of the pitch line. It is usually advisable to make gears on the interchangeable system, that is, so that any gear will run with any other of the same pitch; this is accomplished by using the same rolling circle for all gears of the same pitch, and it is customary to make the diameter of this circle equal to the radius of the smallest pinion in the set, the result being radial flanks for this pinion, which custom has decided shall have twelve teeth.

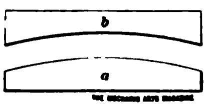


FIG. 2.

Now, suppose we wish to make a pattern of a gear of certain circular pitch: First find the diameter of the rolling circle, then turn up a wooden disk as at *R*, Fig. 1, of exactly this diameter; let into the edge of it, as at *g*, a triangular piece of sheet steel, one point of which has been carefully sharpened so as to extend about $\frac{1}{16}$ of an inch below the under surface of the disk. Then make two sheet-zinc templets *a* and *b*, Fig. 2, one (*a*) to fit the inside of the pitch line, and the other (*b*) to fit the outside. Now fasten to the drawing board a square piece of sheet zinc, and scribe upon it a portion *PP*, Fig. 3, of the pitch circle of the gear. Brad down templet

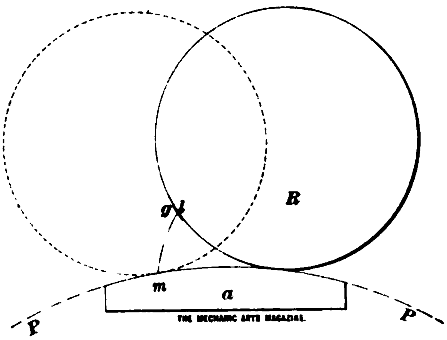


FIG. 3.

a, as in Fig. 3, so that the curved edge coincides exactly with the pitch line; then, using the rolling circle, that is the wooden disk, "roll out" the face *m l* of the tooth; this operation is clearly indicated in Figs. 1 and 3. Remove templet *a*, and on the other side of the pitch line *P P*, fasten templet *b*,

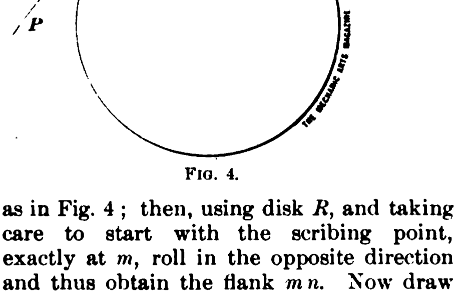


FIG. 4.

as in Fig. 4; then, using disk *R*, and taking care to start with the scribing point, exactly at *m*, roll in the opposite direction and thus obtain the flank *m n*. Now draw the addendum and root arcs *l x* and *n y*, Fig. 5, and through the center of the tooth

draw st towards the center of the pitch circle. Remove the square piece of zinc, Fig. 5, file out the profile $ynmlx$, and fasten, as in Fig. 6, to a straightedge that is long enough to reach beyond the gear center; do this in such a manner that one edge coincides exactly with the center line st of the tooth. Stick a needle into the center of the gear; cut a notch n into the straightedge at

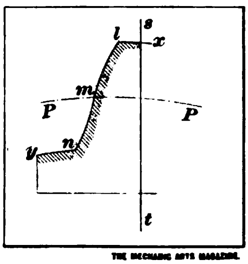


Fig. 5.

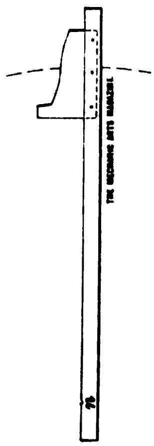


Fig. 6.

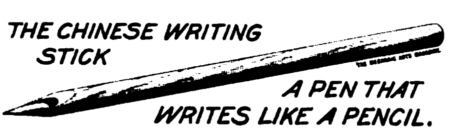
a distance from the pitch line on the templet exactly equal to the pitch radius of the gear. Space the pattern blank, and lay off the tooth thicknesses all around; then, placing the notch n against the needle, scribe the outlines of one side of all the teeth; reverse the templet and scribe the other sides.

For involute teeth the templet is used in a precisely similar manner; but, to obtain its outline, instead of using a rolling circle, use a portion of a disk the same diameter as the base circle determined in the usual manner; attach to this a piece of spring steel so that it can be unwrapped from it, and with a needle clamped thereto, scribe the true involute profile. Then cut out, attach to a straightedge, and use as before.

A BOXWOOD WRITING STICK.

Alpha, Cincinnati, Ohio.

Some years ago, when first employed as draftsman in a large establishment in the east, I was told that it was the custom in



that office to use the Chinese writing stick, instead of an ordinary pen, for printing all letters and figures on drawings. The idea was new to me, but I soon got accustomed to the stick; in fact, I came to prefer it to any pen I had ever tried. Since then I have wondered why it is not in general use, for it is certainly unequaled for some classes of work, particularly if, as in the office referred to, drawings are made and inked in on bond paper and blueprinted direct instead of from tracings. The illustration clearly shows the form of the stick; it is made of boxwood, a little slimmer than an ordinary pencil. To make, you sharpen the end carefully, flatten off one side, and hollow this out with your pocketknife, letting the hole at the deepest part go just about through. Towards the point, for $\frac{1}{4}$ inch or so, the hollow is simply a groove for the ink to flow down. The writing on the sketch was done with the stick I use for ordinary lettering; I have three, one for each weight of letter and figure I use.

TO DRILL GLASS.

F. W. S., Marilla, N. Y.

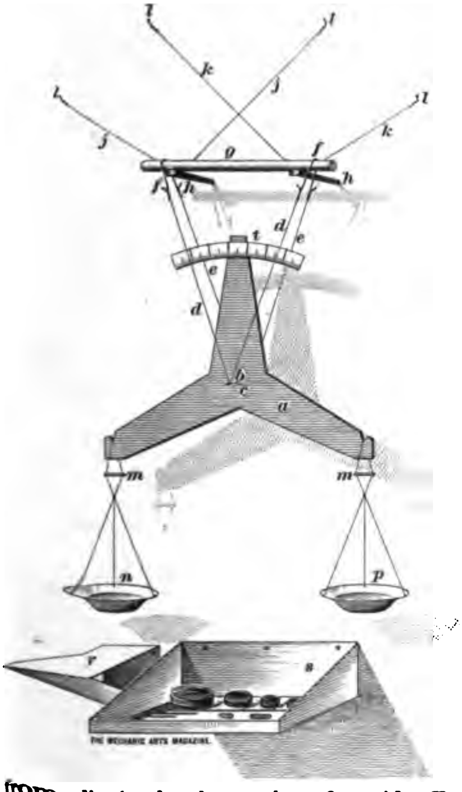
In The Mechanic Arts Magazine, March 1899, Answers to Inquiries, No. 49, you describe a very excellent way to drill glass. The following is another way which I have used myself and know to be all right: Use a common flat drill, tempered very hard by cooling in salt water; put a block of soft wood under the glass, and drill with fairly light pressure; lubricate freely with turpentine in which camphor gum has been dissolved.

COMPLETE SET OF PHOTOGRAPHIC SCALES AND WEIGHTS FOR TEN CENTS.

Kodaker.

The accompanying figure is an exact representation of a set of scales and weights that I made one morning not long ago, and that cost me in cash just 3 cents; as I made use of some things that I found about the house, I put the actual cost down at 10 cents. I use it in my dark room for weighing out so many grains of this and so many grams of that, when preparing the solutions. The smaller weights are accurate to $\frac{1}{100}$ of a grain, and a weight of $\frac{1}{8}$ of a grain distinctly disturbs the balance of the scales. So much for the accuracy of the rig. I made it in the following manner: I happened to have a piece of $\frac{1}{4}$-inch poplar, about 12 inches square; out of it I sawed the three-legged-piece a. Holding this horizontal, I balanced it on the point of needle b, then pushed the needle through; from the opposite side, and as close as possible to needle b, I pushed through another

needle c. I then threaded the needles with silk threads d and e, and tied the ends to hairpins f, bent as shown; hanging these over a wooden rod g (whittled out of a piece of wood from the cellar) I supported the whole on two 4-inch cut nails h. It was a problem how to hang the thing up without driving these nails into and thus disfiguring the wall; but this was soon solved. I filed a notch behind the head of each nail, and, after driving four pins l obliquely and downwards into the plaster wall, as shown, I made the nails perform the office of struts, so that they merely press against the wall, the silk threads j and k being in tension and kept



from slipping by the notches aforesaid. For scale pans, I took two pie dishes n and p, drilled three holes in each with the point of a pocket-knife blade, threaded them, and hung them over the notches in a, afterwards inserting ½-inch lengths of match-wood m to keep the pans swinging freely. A white card t, neatly graduated and pasted to the upper leg of a, completed the scales. I balanced them by sticking pieces of cardboard to the back of a until the upper leg was approximately vertical.

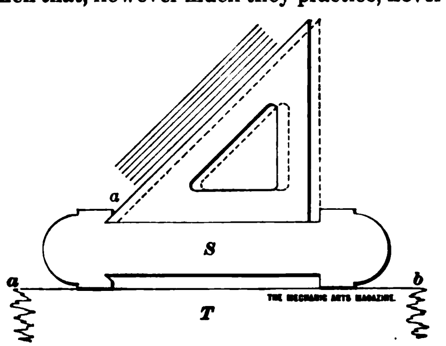
For the weights I bought 2 ounces (carefully weighed) of tinned wire about $\frac{1}{32}$ of an inch in diameter, for which I paid 3 cents. This I took into the yard behind the house, straightened out, and doubled over a wire nail driven into the fence; I then cut it in two, getting in this manner two separate 1-ounce weights, one of which I coiled up. The other I again doubled on itself and cut in two, thus getting two ½-ounce weights, one of which I coiled up as before. I went on in this way until I got down to two 15-grain pieces, each about 11½ inches long; one of these I twisted up to be used as one of the weights; the other length I divided, taking one-fifteenth of it for the 1-grain weight, two-fifteenths for the 2-grain, and so on. As a holder for the weights, I took an old cardboard letter-paper box s, and cut it down as shown, so as to get at the various weights easily. As a support for the weight pan n I used the lid of the above box cut up and built into a triangular frame r and pinned to the wall as shown.

The scales are quite steady, and, being suspended by four threads, as rigid as one could wish.

THE SIMPLEST OF SECTION LINERS.

Harry Bible, Denver, Col.

IN THE MECHANIC ARTS MAGAZINE, February, 1899, in an article entitled "Drafting for the Patent Office," Mr. Palmedo says that, so far, no machine has been invented that usefully facilitates the work of section lining—that the best section liner is a trained eye and a skilful hand. In the main Mr. Palmedo may be right, but there are some men that, however much they practice, never



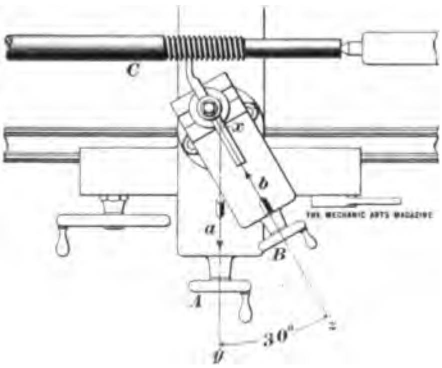
become expert at this work, and to them I can recommend the exceedingly simple device illustrated here. I can operate it just as fast as it is possible to handle the ruling pen, know that my spaces are equal, it saves my eyes from undue strain when

there is any considerable amount of section lining to be done, and it costs next to nothing. Referring to the sketch, T is part of the T square; S is the device, made of any suitable hard wood (I prefer white holly) or celluloid. Each edge of the device gives two spacings; thus, when held as shown, the point of the triangle enters the notch at a; when S is turned over end for end, the square edge of the triangle butts against a and the spacing is reduced. The opening in the other edge of S is made a different length, so that, in all, the one device gives four fixed spacings. To hold, let the thumb of the left hand rest on the T square and place the index finger on S, and the next two fingers on the triangle. To operate, press down on the triangle and push S to the right till it strikes at a; draw line; press on S and push triangle ahead; draw line, and so on.

A HELP IN SCREW CUTTING.

Hugh A. Wilson, Beloit, Wis.

I HAVE FOUND that the following method of cutting a screw thread in the lathe prevents dragging on the right-hand edge of the tool, and makes it an easy matter to adjust the feed. Turn the compound rest, as in the figure, at an angle of 30°; set the tool exactly right for cutting the thread, and run the



point of it up until it just touches the piece C that you are going to thread; then put a chalk mark on the lower feed-handle A. Run the carriage back ready to start the thread, and give the compound feed-handle B a slight turn, feeding the tool in direction of arrow b, until you get the proper cut; then drop in the feed-nut. When the tool reaches the end of the thread, run it out in direction of arrow a by means of the lower handle A, run carriage back for another cut, give B another slight turn, and so on till the thread is finished. By this method, one chalk mark —the one on A—is all you have to make; it is easy to get the feed required in direction of arrow b, and the tool does all the cutting with its left edge, and so dragging is prevented.

AN INEXPENSIVE DRAFTING TABLE.

Wm. P. King, Syracuse, N. Y.

BEING a student in mechanical drawing, but unable to afford a draftsman's table, I built one which serves the purpose tip-top. It is a rig that anybody could put together, so I send it as a contribution to Good Schemes, hoping that others will be glad of the idea. I took a 2′ 6″ × 2″ × ½″ strip of pine—a in Figs. 1 and 2—and nailed it to the wall about 3 feet from the floor. To this I attached a pair of 2-inch hinges, and swung the table from them, as shown. The table is simply a 2′ 6″ × 2′ 0″ × ½″ board, to the under side of which I fastened a toothed rack having six teeth of about 1½ inches pitch. This rack, together with the adjusting leg b, which is simply a stick of pine hinged to block c fastened to the floor, enables the draftsman

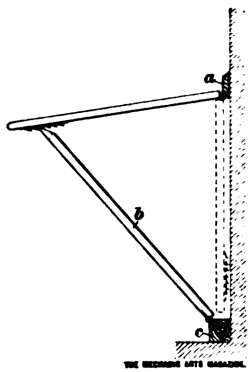


FIG. 1.

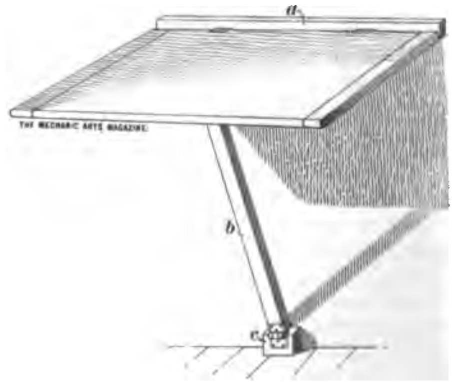


FIG. 2.

to vary the angle of the table at will. When not in use the table is folded down against the wall, as shown dotted in Fig. 1, with the leg b leaning against it, thus taking up very little space.

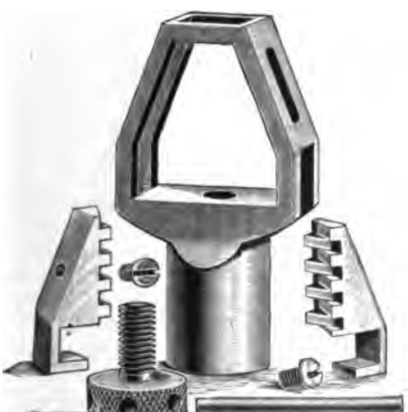
TRADE NOTES

A NEW DRILL CHUCK.

THE ILLUSTRATIONS on this page represent the National drill chuck, manufactured by the Oneida National Chuck Co., Oneida, N. Y. The makers state in their catalogue:

"In placing the National skeleton drill chuck upon the market it is necessary that its workings and construction should be thoroughly understood, as its new and novel appearance will attract the eye of every machinist, and we are aware that it will be closely scrutinized by all interested in the advancement and improvement of tools.

"The construction of this drill chuck should commend itself to all. The flat body and open construction are just the opposite of all other chucks made; therefore, do not be prejudiced because in bringing it out we did not copy after others. This is original, as we do not believe in wearing wooden



shoes because our forefathers did. It operates quickly with the thumb and finger until closed on drill; then a wrench is used to tighten. There is no projection to catch anything, and the flat, open body will not prevent it from drilling a round hole, but makes it easy to clean, light to handle and operate, substantial and durable, giving strength where necessary.

"We make for it the following claims:

"1. The grip to hold a drill is unequaled by any chuck upon the market.

"2. The construction is so simple that any person can put it together in one minute.

"3. The simplicity of construction and arrangement of parts causes the least wear, making it the most durable.

"4. It is the only chuck ever made in which all parts are exposed to view, so that any irregularity can be seen at once.

"5. It can be thoroughly cleaned in one-fourth the time of any other chuck.

"6. All unnecessary material is removed, leaving the strength where required and making it from one-third to one-half lighter than any other chuck made.

"7. It is the only chuck that is easily cleaned, being so open that the dirt will not stay in, and can be blown or brushed out without removing the parts.

"8. It is perfectly balanced and made in all sizes—large and small.

"9. It is the only chuck that is strong and powerful, equally adapted for either light, swift, or heavy work."

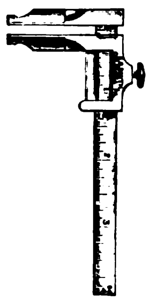
HAND-POWER MODEL DYNAMOS.

THE ELBRIDGE ELECTRICAL MFG. CO., Elbridge, N. Y., inform us that they have lately put on the market an improved Model dynamo, one for direct, and one for both direct and alternating, currents. With this little dynamo, water may be decomposed, incandescent lamps lighted, permanent magnets charged, small motors driven, and a multitude of interesting experiments performed. It may also be used as a motor on any current of proper voltage, thus furnishing power to run light machinery, such as sewing machines, fans, etc. It was designed especially for the use of schools and students of electricity, and to them is invaluable, since it gives the whole theory of the modern dynamo and follows in construction every detail found in large generators. It is made for actual use, all parts being of the best material and put together in the most substantial manner. The armature core is laminated and wound with double-covered wire; its shaft is made of steel and runs in

brass bearings. The commutator has 16 bars, ample brush contact, and will wear for years. All machines are shunt-wound unless otherwise ordered.

TWO USEFUL TOOLS.

E. G. Smith, Columbia, Pa., is making what to the machinist should prove two very useful tools—the "Which Way" level, and the "Columbia" caliper. The level, as will be seen from the accompanying full-size illustration, is designed to tell you immediately "which way" your work is out of level. Under an accurately ground and polished glass cover there is a bubble of air in liquid;



upon a perfectly level surface this bubble floats in the center of the disk, as shown; when resting upon a surface that is out of level, the bubble will move towards the circumference of the disk, always traveling towards the highest part of the surface, and thus indicating which way the work is out.

The caliper tells you the size of the work, and also how much too large or too small. It reads both inside and outside measurements without mental calculation, and is graduated to 16ths of an inch, with a vernier to read to 32ds, 64ths, and 128ths.

BOOKS AND CATALOGUES.

First Lessons in Linear Perspective. By Frederic R. Honey, Ph. B. Size, 9 in. × 12 in.; cloth cover. Published by Charles Scribner's Sons, New York. Price, 80 cents.

This book consists of twenty complete lessons in linear perspective. The first ten lessons were published separately some months ago and reviewed in the July, 1898, number of this magazine. The additional lessons that complete the work comprise the drawing in perspective and in various positions of prisms, pyramids, cylinders, the Greek and the Latin cross, flights of steps, hexagonal and fluted columns, groined arches, and a room furnished and hung with pictures. There is also a lesson on geometry as applied to perspective. The book contains, in all, thirty-eight full-sized plates, all most excellently done. In his descriptions Mr. Honey is as thorough as the English language will permit him to be, and he does not allow a single point to pass unexplained, for which reasons the book is worthy of great popularity with beginners, and should prove of much practical use to teachers also.

One of the most complete tool catalogues issued is that of Montgomery & Co., 105 Fulton street, New York. The book contains over 500 pages, is profusely illustrated, and gives full particulars of the numerous tools and devices that have been most called for in the course of the firm's business. All users of tools, machinery, and supplies, in whatever branch of the mechanical trades they may be engaged, should have a copy.

The Carborundum Co., Niagara Falls, N. Y., have handed us their No. 2, 1898, catalogue; size, 6½ in. × 8 in.; 60 pages. The first part of this book is devoted to an exceedingly interesting historical account of the early methods of manufacturing carborundum, which lead up to the Acheson process as now used. This process is fully described, and is illustrated with reproductions of photographs taken in the above company's works. The chapter includes information regarding the properties and uses of carborundum, especially as compared with those of emery, and the results obtained from a number of actual service tests are given. The remainder of the book is a price list of various carborundum wheels and tools, with sectional dimensioned drawings of a great variety of special forms of wheels.

Theo. Audel & Co., 63 Fifth Ave., New York, N. Y., tell us that they have just published two books by Professor Hawkins, entitled "Hawkins' New Catechism of Electricity" and "Hawkins' New Catechism of the Steam Engine." Price, $2.00 each. Professor Hawkins' works are so well known among engineers that any review by us is unnecessary, the books being up to his usual standard. Audel & Co. make a specialty of selling their publications on easy payments, thus placing them within the reach of all. Any one wishing to inform himself about the practical management of steam plants, and the practical applications of electricity, will do well to obtain copies of the above works.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(81) Herewith I send you a sample of tracing linen that will not take the ink. What is the matter with it, and what shall I do to it to make it work?

J. A., San Francisco, Cal.

ANS.—We have tested the linen and find that it takes ink perfectly. Perhaps there is something wrong with the ink you are using.

***

(82) To settle two arguments, kindly answer the following: (*a*) Does illuminating gas ever freeze in the pipes? (*b*) Is it possible for a person to "scull" a boat without the aid of an oarlock of some description?

F. H. L., Scranton, Pa.

ANS.—(*a*) Illuminating-gas pipes become filled with frozen vapors which form part of the gas, and the gas pipes are then said to be frozen. Of course, the gas itself does not freeze in the pipes, but the vapors accompanying the gas condense and freeze. Unsuccessful attempts have been made to remove the moisture by preliminary freezing in tanks. Another process is to dry by sulphuric acid, which is efficacious as far as the water is concerned, but extreme cold, even with such process, has been known to close up the pipes with frozen benzol. It would appear that the best plan for preventing the freezing of gas pipes is for the gas companies to inject alcoholic vapor into the gas at the works. This apparently prevents the freezing both of the water and the benzol. "The effect of this alcohol vapor," says a renowned German scientist, "is shown in the fact that if, by the action of the cold, separations of water and benzol occur, the alcohol vapor carried along also separates, whereby the freezing point of these separated condensations of water and benzol is forced down so much that they will not congeal even at our lowest temperatures in the winter. They remain in liquid condition, and thereby can freely flow back in the main conduits, where they collect in the condensing pots." (*b*) There are two meanings to the word *scull;* in other words, there are two ways of sculling a boat. In one, the oarsman stands up, and, with one oar used over the stern, propels the boat by imparting to the oar a twisting motion from side to side, as if in imitation of the action of a screw. In the other, two long spoon-bladed oars, or sculls, are used, and the sculler sits upon a seat near the center of the boat, and rows with both hands at once, resting the oars in oarlocks, which are usually outrigged. The sculler's seat may or may not be a sliding one. In sculling with one oar over the stern, the oarlock is an assistance, but is not absolutely necessary.

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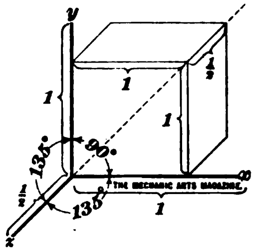
(83) (*a*) What is "cavalier" perspective, as mentioned in THE MECHANIC ARTS MAGAZINE, February, 1899, article entitled "Drafting for the Patent Office"? If a full answer to this question would occupy too much space, kindly refer me to a book on the subject. (*b*) Also, give me the names and prices of good works on the following subjects: mill engineering, bridge engineering, and mining engineering. I have no objection to advanced mathematics in any of these works.

J. A. P., Providence, R. I.

ANS.—(*a*) *Cavalier* perspective is one of various methods of making a perspective representation of an object by means of parallel projection, as against polar projection, used for true perspective. The methods referred to all consist in drawing the outlines of the object parallel respectively to three axes x, y, z, assumed in the plane of the drawing, and representing the angular parallel projection of three orthogonal axes imagined within the body to be drawn. The number of such imaginable projections is very great, but, in practice certain distinct ones are used, one of which is the so-called cavalier perspective. In this, the angle between x and y is 90°; the other two angles are each 135°, and the scales employed for the axes are relatively as $x : y : z = 1 : 1 : \frac{1}{2}$. (*b*) Rankine, "Machinery and Mill Work," $5.00; "The Practical American Millwright and Miller," by David Craik, $3.50; "Theory and Practice in the Designing of Modern Framed Structures," by Johnson, Bryan, and Turneauve, $10.00. There is no complete publication in mining engineering. Geo. G. Andre's "Practical Treatise on Coal Mining" (2 vols. $15.00), and G. C. Greenwell's "Coal Mining" ($6.00) are standard works, but are decidedly English. The foregoing works can be obtained through The Technical Supply Co., Scranton, Pa.



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(84) (*a*) Please tell me how to calculate the amount of water necessary to condense the steam from any engine, the condenser being either jet or surface. (*b*) How much power can I get from an impulse waterwheel 52 inches in diameter, fitted with Pelton buckets, under the following conditions: diameter of jet, ½ inch; water pressure, 80 pounds, from the street main through a ½-inch pipe 150 feet long; number of revolutions per minute, 250.

J. T. M., New Albany, Ind.

ANS.—(*a*) A very simple rule for calculating the amount of condensing water, with as great a degree of accuracy as is usually required, is the following: Divide 1,000 by the difference between 110 and the temperature of the condensing water; multiply the weight of steam to be condensed by this quotient, and the result will be the weight of the condensing water required. (*b*) Owing to frictional losses, you

could not get more than a small fraction of a horsepower, possibly $\frac{1}{16}$ horsepower, from the water that would flow through the $\frac{1}{4}$-inch pipe under conditions you have named. It would be impossible to get a speed of 250 revolutions per minute with a 52-inch wheel using the water from the $\frac{1}{4}$-inch pipe.

***

(85) Kindly show how to lay out an elbow 3 feet in diameter, made of $\frac{3}{8}$-inch plates. I want this layout made by the right-angular method.

R. Q., Lorain, Ohio.

ANS.—In order to obtain a "layout," or pattern development, for any object, it is necessary first to produce a correct representation or drawing of the object in one or more positions; or, the same results may sometimes be obtained by the use of various sections taken on different planes. The object in question is a four-pieced square elbow, and, before proceeding to describe the pattern, it will be well to illustrate a simple method of finding the line of intersection, or the miter line. This method is applicable to elbows having any number of pieces, and, by slight modification, to elbows of different angles. In Fig. 1 the angle abc is drawn by the use of the T square and 45° triangle; with a radius nearly equal to ab, and with b as center, describe the arc ef; this arc is then divided, by spacing, into a number of parts—*one less than the number required in the desired elbow*—and a line drawn from b through the division in the arc nearest the line ab will be the correct miter line for our elbow. We may now proceed directly with the development of the pattern. Place a half section of the elbow ghi, as shown, on ab. Divide the half circle ghi into a convenient number of equal parts, and draw perpendiculars to ab from each of these points, continuing them until they cut the line bd. Extend the line ab indirectly towards j, and, starting as near b as is convenient, set off twice as many spaces as there are in the half section of the elbow. From each of these points erect perpendiculars, as shown. Now, with the T square, project each intersection of the line bd, with the lines drawn from the half section, on to the perpendiculars drawn from bj. It will be readily seen that the irregular curve ABC may be produced by tracing through the diagonally opposite corners of the small rectangles thus formed. The curved line ABC is the correct pattern for the "cut" of the elbow; and, as matters relating to the length of throat required are optional with the mechanic, it will be seen how these lengths may be changed without affecting the angle of the elbow. The four-pieced elbow shown may be cut without waste of stock by reversing the patterns for the sections as shown in Fig. 2, the curve being the same in each case. In large elbows of the size mentioned in the question, it will be found practicable to make up the blank from two or more sheets of metal, allowing the seams to be in the position shown by the dotted lines in the central portion of the figure. The dotted lines at each side of the blank represent the stock added for laps, which is of course a matter of choice with the mechanic. While the same methods of development are made in all elbows of the class mentioned, there is, in this particular case, an element that would affect the practical working of the method, and that is, the thickness of the metal worked. Boilermakers are accustomed to add seven times the thickness of the material used to the length actually needed for the circumference of the desired circle, in order to bring the diameter to the correct size when the work is formed up. Now, it is obvious that, if we add seven times the thickness of the metal (which would be $2\frac{5}{8}$ inches in the present case) to one end of our pattern sheet, it will not be correct, as this extra stock should be distributed through the entire circumference of our elbow, and the pattern should also partake of this increase. To make allowance for this property of the material, the following method may be used: On the line bj, Fig. 1, add the measurement required for the extra thickness of the stock, at jk; with a radius equal to lk, and with l as center, describe an arc cutting the perpendicular extended from C; from this point of intersection draw a line to the point l, and extend the dotted lines in the manner indicated in Fig. 1; make lA' equal to lA, and continue through each perpendicular in like manner. The curve $A'B'C'$ may then be produced, which will be the correct pattern for the elbow required. Fig. 3 shows the usual method of laying off edges for elbows made of heavy metal, the stretching for the flanges being done while the metal is hot. The rivets are also set while hot, and are placed to one side of the intersection line, giving the work a finished appearance.

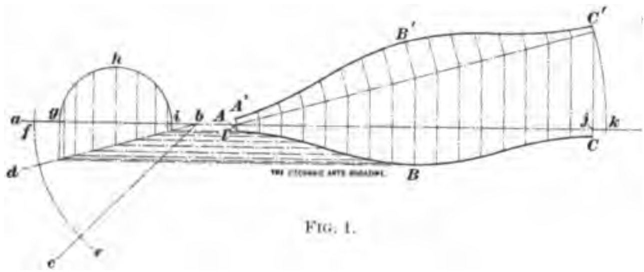

FIG. 1.

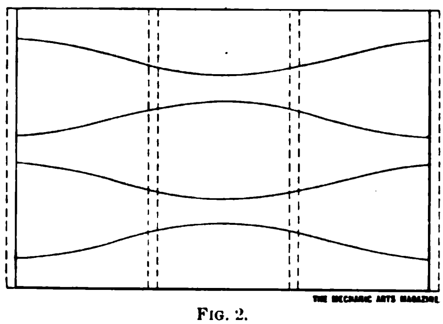

FIG. 2.

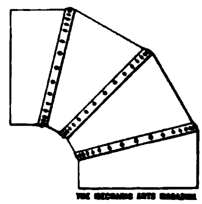

FIG. 3.

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(86) (a) Please explain the method of procedure when designing the foundation for an anvil that is to receive the blows of a falling weight or steam hammer. For example, what must be the area of the foundation for an anvil that is to receive the blows of a 500-pound weight after falling 20 feet? The earth in which the foundation is to be built will carry a static load of 4,000 pounds per square foot.

(*b*) If a water-service pipe from street main to front cellar wall is ¾ inch in diameter, and is enlarged to 1 inch diameter inside of cellar, carried thus for 50 feet to rear of building, then continued with the same diameter to the third floor, branches being taken off for fixtures at each floor, all 1 inch in diameter, how much more water can be obtained than if ¾-inch piping were used throughout the house? Assume any convenient water pressure and total length of piping. X.

ANS.—(*a*) A rational solution of this problem involves the use of a number of factors whose values cannot be determined with sufficient accuracy to make the results of much practical value; it is, therefore, customary to depend on simple formulas based on practical experience. The following formulas for calculating the weight of foundation to be used under the anvil block, and the probable pressures on the earth under the foundations, are given by a good authority:

Let G = weight of the falling parts of the hammer;
H = height of fall, in feet;
W = weight of material in foundation;
P = total pressure on earth under foundations.

Then, for a simple falling weight—for example, a steam hammer in which steam does not act above the piston to increase the force of the blow—

$$W = 1.8\,H\,G,$$

for hammers used in forging iron; and

$$W = 2\,H\,G,$$

for hammers used in forging steel. For steam hammers in which live steam acts above the piston, so as to increase the force of the blow, make the weight of the foundation 30 per cent. greater than the value obtained by the above formulas. The total pressure on the earth on which the foundation rests is given by

$$P = 9\,G\,H + W \text{ to } 18\,G\,H + W,$$

for hammers used for forging small billets;

$$P = 18\,G\,H + W \text{ to } 28\,G\,H + W,$$

for hammers used for welding piles of bars into blooms: and

$$P = 28\,G\,H + W \text{ to } 38\,G\,H + W,$$

for hammers used for forging steel. (*b*) There is so much uncertainty regarding the frictional losses in the different pipes and fittings of such a system that we cannot make an estimate of the gain in flow that would have any practical value.

***

(87) I want to know how to build an oven that will dry bricks quickly. The bricks are made of sawdust and coal mixed together and pressed into 7″ × 4″ × 8″ blocks, perforated with a number of holes. When pressed, each brick contains about 4 ounces of water, which has to be dried out. The oven I am now using is about 40 feet long, 4 feet wide, and 5 feet high, and will hold about 4,000 bricks. It is built of brick, and is heated with fifteen 1¼-inch steam-pipe coils. The bricks are placed on thin boards on "buggies" similar to those used in brickyards; but it takes 2 days to do the drying. If you can tell me of some kind of oven that will hold from 400 to 500 bricks, and dry them quickly, I shall appreciate it very much.

N. M. D., Mt. Oliver, Pa.

ANS.—You will understand that heat is not the dryer; heat only helps the air to absorb moisture from the bricks. The air is the real drying agent, and when the air is nearly saturated with vapor by absorbing the moisture from the bricks, you must remove this air from the kiln and replace it with more *dry* air; otherwise, the air in the kiln, although hot, will not dry the bricks. What you need is an arrangement for circulating very dry air through the kiln. This can be accomplished by having a slatted floor, and a space of about 2 or 3 feet under the floor, and a number of steam pipes in the space. Then you require an opening to allow fresh air to enter the space under the steam pipes and another hole in the ceiling to allow the moisture-laden air to escape up through a ventilating shaft in the roof. Thus you will have a constant stream of hot, dry air passing up through the bricks. Place a damper in the vent stack and you can control the current easily.

***

(88) On an incandescent-lighting circuit, run on the three-wire system, will both the ammeters give the same reading when there are more lights on one side than on the other? For instance, if there are two hundred 16-candlepower lamps on one side, and one hundred on the other, will one ammeter show about 100 amperes, and the other about 50, or will they both show about 75 amperes?

C. F. I., Scranton, Miss.

ANS.—The two ammeters, being placed in the outer conductors, will register independently of each other the current passing through those conductors. In the case above mentioned, therefore, the ammeters would indicate 100 amperes and 50 amperes, respectively.

***

(89) (*a*) To settle an argument, kindly answer the following question: Is the over stroke of a locomotive engine more powerful than the under stroke? By this I mean, can a heavier load be started when the crank-pin is vertically *above* the axle than when it is vertically *under* the same? (*b*) Would air at a temperature of 80° become cold enough to freeze water, if it were driven by an air pump at a high rate of speed? R. E. P., Brown's Valley, Minn.

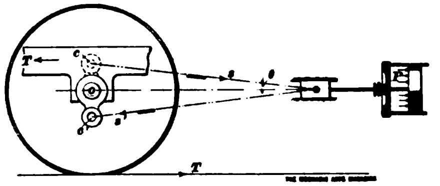
ANS.—Let

P = total pressure on piston;
T = tractive force;
R = radius of driver;
r = radius of crank;
θ = angle of the connecting-rod when the crankpin is at c above the axle.

Then, $\dfrac{P}{\cos\theta}$ = pull s exerted by the connecting-rod on the crankpin. Taking moments about the center o of the axle, the moment of s is

$$s \times r\cos\theta = \frac{P}{\cos\theta} \times r\cos\theta = P\,r,$$

and the moment of the rail pull T is $T\,R$. The other forces acting on the driver and axle are the weight



supported and the reaction of the frames. Evidently, however, the lines of action of these forces pass through the center o, and they have therefore no moment about o. We have, then,

$$T\,R = P\,r, \text{ or } T = \frac{P\,r}{R}.$$

Now, when the crankpin is at c', $s' = \dfrac{P}{\cos\theta}$, the moment of s' is $\dfrac{P}{\cos\theta} \times r\cos\theta = P\,r$, and $T = \dfrac{P\,r}{R}$, as before. The rail pull T is just equal and opposite to the drawbar pull, since these two forces are the only horizontal external forces acting on the locomotive. It follows, therefore, that the same load can be started, whether the pin is vertically above or below the axle. (*b*) No; the temperature of the air would be increased.

***

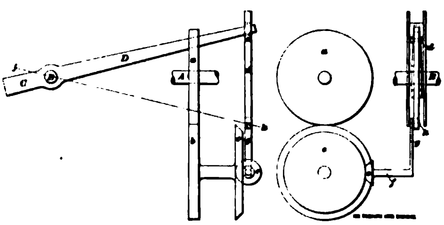
(90) With reference to the gasoline engine illustrated in HOME STUDY MAGAZINE, January, 1899, article entitled "The Gasoline Engine," kindly answer the following questions: (*a*) Would it be

practicable and economical to regulate the speed by attaching the governing mechanism to the needle valve *F*, leaving the volume of air taken in constant for all loads. (*b*) Would it not be difficult, on a cold day, to get the engine to start, with cylinder head *Y* and pipe *G* cold, on account of the gasoline evaporating slowly? (*c*) What is the ratio between the volume of liquid gasoline and its vapor at atmospheric pressure? (*d*) Are any of the illustrated features of the above mentioned engine patented, that you know of? W. C. B., Litchfield, Ill.

ANS.—(*a*) The method of governing proposed is used on some forms of gas and gasoline engines. In case the load is practically constant and near the full capacity of the engine, the regulation of the gas supply alone, leaving the air supply constant, is probably the best method that can be adopted. If the load varies through a wide range, however, the gas might be cut off entirely at light loads, and a considerable fluctuation in speed would result; in this case it is considered better practice to regulate the flow of the mixture of gas and air, as is done in the engine under consideration. (*b*) We believe there is some special method of starting the engine under these circumstances. See HOME STUDY MAGAZINE, February, 1898, article entitled "Gas Engines." (*c*) We are unable to find any information on this point. The following statement, quoted from a recently published book, may be of interest to you: "The vapor of commercial gasoline at 60° F. is equal to 130 volumes of the liquid." (*d*) Several patents have been issued to the makers of this engine, and they probably cover all novel features.

***

(91) I desire a general solution of the following problem: Referring to enclosed sketch, if 1,000 pounds is applied to shaft *A*, what percentage of it will be transmitted through the mechanism, and remain as useful effort to lift arm *C* of the lever fulcrumed on shaft *B*, the force passing through the gears *a* and *b*, bevel gears *c* and *e*, shaft *f*, crank *g*,



connecting-rod *h*, crosshead from arm *d*, to position shown by the center line *jk*? Arm *C* carries a uniformly distributed load of 5,500 pounds; arm *b* is seven times as long as arm *C*.
S. E. S., White Plains, N. Y.

ANS.—A general solution of this problem would be of no practical use to you, because you evidently do not understand the effect of frictional resistances upon the efficiency of machinery. In another part of this number you will find the first part of an article entitled "Sliding Friction"; read and thoroughly understand this, and then study the second part when it appears in the May number; you will then be in a position to solve the above problem.

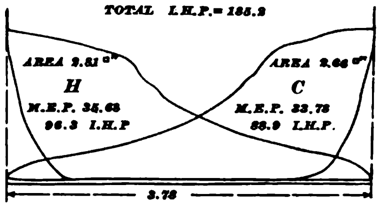
***

(92) (*a*) Please tell me how to make a paste suitable for mounting a gelatine photographic print face down on glass. (*b*) Can you tell me of a book on the coloring and mounting of photographs on glass?
F. S. D., Berkley, Mass.

ANS.—(*a*) Use a thin solution of plain gelatine. Soak the gelatine in cold water over night, and, after pouring off the surplus water in the morning, warm the swelled gelatine over a water bath; and, when melted, dilute gradually with hot water until the gelatine has the consistency of thin cream. Warm the glass on which the print is to be mounted, and coat it with the warm gelatine paste; then, when glass is cool, squeeze the wet print into contact with the gelatine surface and leave to dry. (*b*) We know of no book devoted exclusively to the coloring of photographs on glass.

***

(93) Enclosed find cards of engine of which I have lately been given charge. (*a*) What is the horsepower of the engine? (*b*) Tell me all you can about the engine from the cards. (*c*) There is a snapping noise in the cylinder, as though water were



siphoned over into it from the boiler; but it is the same whether the water is high or low. Can it be caused by the piston rings, or what do you think is the trouble? I should have mentioned that the steam piping is 6 inches in diameter.
W. B. A., Torrington, Conn.

ANS.—(*a*) The horsepower, calculated from the data given on the card, is 185.2 I. H. P. Are you sure you have given the correct scale for the indicator spring? We have never before heard of a spring having that scale. (*b*) The general performance of the engine, as indicated by the cards, is fairly good, and it is probable you will find it difficult to make any change that will improve the working of the engine to any great extent. The most serious faults shown by the diagrams are the following: The steam line falls considerably before cut-off begins, showing that the steam is throttled; the cause may be that the steam pipe is too long, or there may be some obstruction, such as a number of bends in the pipe, a partly opened valve, or restricted steam ports. Cut-off takes place later on the head than on the crank-end; the result is that about 7½ horsepower more work is done in the head than in the crank-end. (*c*) It is probable that the noise is caused by the piston rings. It often happens that, when the rings enter the counterbore, the pressure of the steam closes them, causing the snapping sound about which you speak.

***

(94) What is the process by which ginseng roots, burdock roots, and yellow dock are prepared for the market? This question is perhaps a little out of your line, but I thought you could give me some information, or, at any rate, tell me where I could get the information. R. H. S., Trumansburg, N. Y.

ANS.—The roots of these three plants are dug out in early autumn, cleaned, and dried.

***

(95) What, in your opinion, is the best kind of dry closet, for use where there is no water?
C. M. G., Georgetown, Ohio.

ANS.—The best closets for use in places where water cannot be had for flushing purposes, is the earth closet. It should, of course, be set outside the main building. Earth is a excellent deodorizer, and an earth closet—which is flushed with earth, so to speak—is considered by sanitarians to be the best where water cannot be had.

SELF HELP

WORK, THE WATCHWORD OF SUCCESS.

"WORK and be thorough," is our counsel to men who seek to rise by self-improvement.

There is no want of desire on the part of most persons to arrive at the results of self-culture, but there is a great aversion to pay the inevitable price for it—hard work. Dr. Johnson held that "impatience of study is the mental disease of the present generation," and the remark is still applicable. We may not believe that there is a royal road to learning, but we seem to believe very firmly in the "popular" road. In education we invent labor-saving processes, seek short cuts to science, or learn French and Latin "in twelve lessons" or "without a master." We resemble the lady of fashion, who engaged a master to teach her on conditions that he did not plague her with verbs and participles. We get our smattering of science in the same way; we learn chemistry by listening to a short course of lectures enlivened by experiments, and when we have inhaled laughing gas, seen green water turned red, and phosphorus burned in oxygen, we have obtained our smattering, of which the most that can be said is, that, though it may be better than nothing, it is yet good for nothing. Thus we often imagine we are being educated while we are only being amused.

The acquirement of bits of information, without study and labor, is not education. It occupies but does not enrich the mind. It imparts a stimulus for the time, and produces a sort of intellectual keenness and cleverness; but without an implanted purpose and a higher object than mere pleasure it will bring no solid advantage. In such cases knowledge produces but a passing impression—a sensation, and no more; it is, in fact, the merest epicureism of intelligence—sensuous, but certainly not intellectual. Thus the best qualities of many minds, those which are evoked by vigorous effort and independent action, sleep a deep sleep, and are seldom called to life, except by the rough awakening of sudden calamity or suffering which, in such cases, comes as a blessing if it serves to rouse up a courageous spirit that, but for it, would have slept on.

Accustomed to acquire information under the guise of amusement, people will soon reject that which is presented to them under the aspect of study and labor. Learning their knowledge and science in sport, they will be too apt to make sport of both; while the habit of intellectual dissipation, thus engendered, cannot fail, in course of time, to produce a thoroughly weakening effect both upon their mind and character. "Multifarious reading," said Robertson of Brighton, "weakens the mind like smoking, and is an excuse for its lying dormant. It is the idlest of all idleness, and leaves more impotency than any other."

The evil is a growing one, and operates in various ways. Its least mischief is shallowness; its greatest, the aversion to steady labor which it induces, and the low and feeble tone of mind which it encourages. If we would be really wise, we must diligently apply ourselves, and confront the same continuous effort that our forefathers did; for labor is still, and ever will be, the inevitable price set upon everything that is valuable. We must be satisfied to work with a purpose, and wait the results with patience. All progress, of the best kind, is slow; but to him who works faithfully and zealously the reward will, doubtless, be vouchsafed in good time. The spirit of industry, embodied in a man's daily life, will gradually lead him to exercise his powers on objects outside himself, of greater dignity and more extended usefulness. And still we must labor on; for the work of self-culture is never finished. "To be employed," said the poet Gray, "is to be happy." "It is better to wear out than to rust out," said Bishop Cumberland. "Have we not all eternity to rest in?" exclaimed Arnauld.

Work, the watchword, calls from everywhere for men to equip themselves with knowledge, for the struggle of life. Progress in knowledge should be the aim of old and young; the needs of the times demand it. Man was designed for work, not for ease.

Most people want the results of self-culture without the work. Knowledge acquired without study and labor is not education. Those accustomed to learn easily will reject that which is accompanied by study and labor. We should desire to rise by study and hard work, whose results will endure the tests of time and use.

FROM FARMER BOY TO COLONIAL GOVERNOR.

THE American farm has given this nation and the world at large some of the most illustrious men that have within the century just closing adorned the earth and strengthened the race by their presence, influence, and ability.

Nature's true noblemen have, from Washington to Lincoln, and from Lincoln to Garfield, come from the quiet, charming, virtuous country homes of the land, to lead Americans in every social struggle, and in every national crisis, to victory and to renown.

Witness the following narrative of a noble soul's success, the triumph of a brave farmer's boy, the march from the plow to the highest honors a grateful nation can bestow, the governorship of an imperial domain, the Philippine Archipelago. This historic group of fourteen hundred islands, with ten millions of people, is, for General Merritt, its first governor, as it is for the United States of America, a new field. Appointed to this high office, General Merritt is not only honored, but has before him duties that will demand the display of all the qualities of greatness he has already shown, and others that he will, no doubt, disclose. Said General Banks, "Responsibility educates men." General Merritt has not only to fight, but, by wisdom, to pacify, organize, and rule these people, for their own good and the honor of the United States.

Wesley Merritt, born in New York City, in 1836, was graduated at West Point, April 5th, 1862; took part in Stoneman's raid about Richmond, and had command of a cavalry brigade; he was breveted major for valor at Gettysburg, after having received successive brevets for bravery at Yellow Tavern, Hawes' Shop, and Winchester. At Five Forks, he was, for courage, breveted brigadier- and then major-general in the regular army; and, later, was commissioned major-general. He did good service on the frontier till 1882, when he was put in charge of West Point. He afterwards served again at Fort Leavenworth.

The following interesting facts taken from "The New York Herald" and "The Army and Navy Journal" show the inherent power and extraordinary gifts of this illustrious soldier. Merritt won fame and honor as Sheridan's chief officer in the great battles of the Civil War. He was an unrelenting warrior, once fighting nine battles in ten consecutive days.

His father, John Willis Merritt, was a New York lawyer. When Wesley was four years old, his father, having a large and increasing family, abandoned law for agriculture, and bought a farm at "Looking-Glass Prairie," near Belleville, Illinois, not far from St. Louis. The boy Wesley attended a school of Christian Brothers at Belleville. He worked for three years on the farm with his brothers, raising corn and pork.

Young Merritt often drove the farm team seventeen miles to town, getting fifteen cents a bushel for his corn. There was little money then in circulation, and pasteboard checks were used instead. At sixteen, Governor Bissell secured him a cadetship at West Point.

"Up to that time," said Merritt, "I had no idea of ever becoming a soldier. My ambition was to be a good lawyer and politician, and enter public life. I believed that my forte lay in discussion and public speaking. However, when my father pointed out the great advantages of a West Point education, a careful consideration of the subject convinced me of its wisdom. I accepted his views and went to West Point. The course of study was for five years. I got along very well. I did not stand high in my class except in English, and was rather slow in mathematics. I think I was in the only class ever graduated from that institution which took a course occupying full five years."

The farms of America make of the youths who toil thereon the most resourceful and self-reliant men in the world.

"Aim at the highest prize: If there thou fall,
Thou'lt haply reach the one not far below."

CHEERFULNESS AT WORK.

NEVER did Thomas Carlyle write nobler lines than these: "Give us, O give us, the man who sings at his work be his occupation what it may! He will do more in the same time, he will do it better. One is scarcely sensible to fatigue whilst one marches to music. Wondrous is the strength of cheerfulness, altogether past calculation its powers of endurance."

ANDREW CARNEGIE.

A NOTABLE EXAMPLE OF SELF-ACHIEVED SUCCESS.

THE subject of this sketch was born on the 25th of November, 1837, in Dumfermline, near Edinburgh, Scotland. His father, William Carnegie, was a master linen weaver. Andrew received his early education from his mother, but at the age of eight he was sent to the local schoolmaster. Scarcely had he started on his studies, however, when his father was deprived of work through the introduction of steam power. So the family left Scotland and came to Allegheny City, Pa.

At the age of twelve, Andrew did his share towards the support of the family by working as a bobbin boy in a cotton factory, at $1.20 per week. By constant study and observation he learned to run a small steam engine in the cellar of the factory, and afterwards to act as clerk for his employer.

At the age of fourteen he obtained a position as messenger boy for the Ohio Telegraph Co., where he finally became an operator at $25 per month. This was a welcome change, as the death of his father had left him the sole support of the family.

His next position, as an operator, was with the Pennsylvania Railroad Company. Here he rapidly mastered the details of train despatching, and perfected a system so superior to all existing methods that he was promoted, first, to the position of secretary to the superintendent, and afterwards to the superintendency of the western division, at the age of twenty. He was instrumental in introducing the Woodruff sleeping cars, and from his investment in them realized the beginning of his fortune.

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ANDREW CARNEGIE.

In 1861, he rendered good service to the Government, in charge of the military railroads and telegraphs, but his next business venture was in the famous Storey Farm, Oil Creek, Pa., which he bought, with two others, for $40,000. Its value soon rose to $5,000,000, and one year's dividend alone amounted to $1,000,000.

After disposing of his interest in this business, he started the Keystone Bridge Works, of Pittsburg, Pa. This was soon followed by the Union Iron Mill and the Edgar Thompson Steel Mill. After buying out his rival, the Homestead Steel Works, and building other great plants, he became, and has remained, the largest iron and steel manufacturer in the world, employing 25,000 men, whose monthly wages aggregate $1,125,000.

The reasons for his success are not hard to find. Hampered by poverty and hardships, but employing all his available time in self-improvement, he was bound to rise. He gladly acknowledges that the education which enabled him to advance was gained by the study of books loaned him by a Colonel Anderson, of Allegheny, who opened his library to working boys and men on Saturdays. In a like spirit of philanthropy, Mr. Carnegie has given large sums to various cities for the foundation of free libraries. His "luck" may be analyzed as the possession of a clear mind, a strong will, the ability to see opportunities, the ambition to take quick advantage of them, and the power of will to "stick" until all difficulties were overcome.

In the face of his experience—and he is only one of many—no man should feel discouraged because his lot is cast "at the bottom of the ladder." Garfield has said, "Poverty is uncomfortable, as I can testify; but nine times out of ten the best thing that can happen to a young man is to be tossed overboard, and compelled to sink or swim for himself. In all my acquaintance I never knew a man to be drowned who was worth the saving."

A PRINTER'S SUCCESS.

Persist, if thou wouldst truly reach thine ends,
For failures oft are but advising friends.

From a printer's apprentice, carrying his dinner in a napkin and working day and night to get a living, Robert Bonner rose to be the owner of millions and a leader in many departments of life. He did not get his fortune by any trick or streak of luck, but by steady, honest effort, careful saving, and prudent investment. Bonner might be called the father of advertising. He saw its value; he dared heights of boldness in calling attention to his wares that amazed his contemporaries. He was always the champion of right, and, at an early age, allowed himself to be turned out of school for his part in defending a boy whom he knew to be innocent. The quickest typesetter in the office of the Hartford "Courant," he, on one occasion, set up the President's message, at the rate of 1,700 ems an hour, to enable that paper to get the message out in advance of other papers.

From Hartford he went to New York, and, in the broader field, soon conquered his way to a place among the prominent, leading, and successful business men of the metropolis. He sometimes invested every dollar he had in bringing his enterprises before the people, but would not get into debt, and always refused to accept credit. When he began on the Hartford "Courant" he got his board and lodging, $25 for the first year, $35 for the second, and $45 for the third. Never having had any school advantages to speak of, he endeavored to learn all he could from the copy he set up. He always saved something. Never accumulating money for the sake of getting rich, he went on the principle of living always within his income, and so his bank account grew. One day after he went to New York he found that he had $70 ahead, and with this opened a bank account, keeping up the deposits until they amounted to $1,000 a week. When he bought the New York "Ledger" it was a little financial sheet. Bonner made it a family journal and employed some of the most noted writers in the country to contribute to it. He paid these contributors such extravagant prices for their work that all the newspapers of the country ridiculed his lack of judgment without considering that he was getting his money's worth out of them in free advertising. So he became immensely rich. He attributed his remarkable success to perseverance.

A GOOD MANNER.

THERE is something really magical about what is termed "a good manner" that impresses itself upon even a stranger. Many a man has "won life's battle" largely by this weapon.

A young man left his Green Mountain home at the age of twenty, and started for the wide West, to seek his fortune. He was used to poverty and hardship, and it did not dishearten him to find himself one day, in a town of Illinois, sixteen miles from Jacksonville, with but a few pennies in his pocket, and no friend within a thousand miles to whom he could look for help. He had just walked from Jacksonville, but his coat over his arm was his heaviest baggage. He placed himself at once in the avenues of business, on the sharp lookout for any opening that might offer. A great sale of property, which lasted three days, was just beginning, and the auctioneer was looking for some one to act as clerk of the sale.

This young man's face and genial air pleased him, and he was at once offered the situation, at two dollars a day. He went to work with a will, and by his winsome manner, ready wit, and obliging ways, won the hearts of the whole crowd before the first day was over. Such a young man those hearty Westerners felt they did not see every day. They must make a fixture of him. So, as soon as the sale was over, they offered him a position as teacher in one of their schools. This he gladly accepted, studying law in his leisure hours. His progress was rapid, and when twenty-one he opened his law office, and began regular practice. A year later he was by the legislature elected attorney-general of the state. The next year he was a member of the legislature. After that he was secretary of the State of Illinois, then judge of the supreme court for three years till elected to congress, where he served as representative and then senator till the end of his life.

Stephen A. Douglas, the young man from the Green Mountains, had high talents, but his pleasant manner, from the beginning to the end of his career, was what gained him the larger share of his popularity and success.

If the history of our citizens of wealth were written," says Hon. William E. Dodge, "we should find that fully three-fourths have risen from comparatively small beginnings to their present position."

VALUE OF CONCENTRATION.

ONE of the hardest tasks to master is to concentrate the whole attention upon the lesson of the morrow ; for the student in college to prepare for the next recitation without running into the ball field, or allowing his gaze to wander around the room, or doing anything else in order to cheat himself out of what he ought to do. In study, as in business, we must not only strike the iron while it is hot, but strike it until it is made hot.

William A. Mowry tells a story of one of the foremost American scholars, who found himself spending two hours a day in preparing his Latin lessons. He determined to get that lesson in an hour and fifty minutes, and succeeded. When he afterwards sat down to learn his Latin he bent every energy to accomplish it in the shortest possible time. He found, by daily trials, that he could learn it in an hour and forty-five minutes, and that the time required was diminishing. Concentrating all his powers upon the task, day by day, he soon found himself studying only an hour and a half upon it, then five, ten, and even thirty minutes less. Encouraged, he redoubled his efforts, and within a few months the lesson could be learned in less than half an hour, a thing absolutely impossible with his habits of study when he entered the school.

It is not, indeed, the quantity of study that one gets through, or the amount of reading, that makes a wise man ; but the appropriateness of the study to the purpose for which it is pursued ; the concentration of the mind, for the time being, on the subject under consideration ; and the habitual discipline by which the whole system of mental application is regulated. Abernethy was even of opinion that there was a point of saturation in his own mind, and that if he took into it something more than it could hold, it had the effect only of pushing something else out. Speaking of the study of medicine, he said : "If a man has a clear idea of what he desires to do, he will seldom fail in selecting the proper means of accomplishing it."

BE AN OAK, NOT A VINE.

THERE is, according to Dr. J. G. Holland, no surer sign of an unmanly and cowardly spirit than a vague desire for help, a wish to depend—to lean upon somebody and to enjoy the fruits of the industry of others. There are multitudes of young men who indulge in dreams of help from some quarter coming in at a convenient moment to enable them to secure the success in life that they covet. The vision haunts them of some benevolent old gentleman with a pocketful of money, and a trunkful of mortgages, and stocks, and a mind remarkably appreciative of merit and genius, who will, perhaps, give or lend them from ten to twenty thousand dollars, with which they will commence and go on swimmingly.

"To me," adds the same writer, "one of the most disgusting sights in the world is that of a young man with healthy blood, broad shoulders, and a hundred and fifty pounds, more or less, of good bone and muscle, standing with his hands in his pockets and longing for help. I admit that there are positions in which the most independent spirit may accept of assistance—may, in fact, as a choice of evils, desire it ; but for a man who is able to serve himself, to desire the help of others in the accomplishment of his plans of life is positive proof that he has received a most unfortunate training, or that there is a leaven of meanness in his composition that should make him shudder."

THE CALL OF CITIZENSHIP.

WE WISH to maintain a republican form of government as a beacon to the world. Then it behooves each citizen to justify his ideal of republicanism in his own personality.* Let us disprove the idea that America is the paradise of the commonplace, by aspiring to a higher degree of intellectual culture than we have yet attained. Let us show to the world that there is a dignity in a cultured mind and heart compared with which the honor of being descended from crowned heads and princes of the blood sinks into insignificance.

WHAT EXPERIENCE TEACHES.

EXPERIENCE teaches that we become that which we make ourselves. Every man stamps his own value upon himself, for we are great or little according to our will. We try to be honest, kind, and true, and little by little we become that for which we strive; and what once was difficult, by degrees becomes less and less so. Activity, goodness, benevolence, and temperance grow by use; and that which was once accomplished with effort becomes easy and natural. Thus a man may *make* himself generous, just, sympathetic, and magnanimous—civil, polite, forbearing, and gentlemanly.

SELF-RESPECT.

SELF-RESPECT is the noblest garment with which a man may clothe himself—the most elevating feeling with which the mind can be inspired. One of Pythagoras' wisest maxims, in his "Golden Verses," is that with which he enjoins the pupil to "reverence himself." Borne up by this high idea, he will not defile his body by sensuality, nor his mind by servile thoughts. This sentiment, carried into daily life, will be found at the root of all virtues—cleanliness, sobriety, chastity, morality, and religion. "The pious and just honoring of ourselves," said Milton, "may be thought the radical moisture and fountain head from whence every laudable and worthy enterprise issues forth." To think meanly of one's self, is to sink in one's own estimation as well as in the estimation of others. And as the thoughts are, so will the acts be. Man cannot aspire if he look down; if he will rise, he must look up. The very humblest may be sustained by the proper indulgence of this feeling. Poverty itself may be lifted and lighted up by self-respect; and it is truly a noble sight to see a poor man hold himself upright amidst his temptations, and refuse to demean himself by low actions.

Self-control and self-respect, its essential concomitant, ensure the production of that true type of man and citizen of whom it may well be written:

He serves his country best
Who lives pure life and doeth righteous deed,
And walks straight paths, however others stray,
And leaves his sons, as uttermost bequest,
A stainless record, which all men may read.

HOW HABIT GAINS IN STRENGTH.

HABIT gains in strength by repetition of the act. Penmanship is a habit of the hand, and so are knitting and sewing. As the habit is perfected we become less and less conscious of the act, and finally do it unconsciously. This is a very important principle in education. Mental processes, like speaking, writing, spelling, etc., must be made mechanical. Here is the right place for mechanical teaching by means of drill. These processes should be made almost wholly unconscious. It is practice and not the learning of rules, that accomplishes the result. These processes should also be made reflexes; as the spinal cord is the organ for reflex actions, we might almost say that spelling ought to be made a function of the spinal cord, like knitting and sewing. One has not been properly taught to spell a word if he can spell it only when he watches the spelling: he should be able to spell it correctly unconsciously. All mental energy expended in watching one's spelling, punctuation, pronunciation, etc. is wasted. If the schools will train students to speak, write, and spell almost entirely without conscious thought of these processes, they will set free mental energy for purposes of thinking, which is equivalent to "furnishing brains." A person who must watch his language when he expresses himself is hampered all his life.

TRUE COURAGE.

"THE greater part of the courage that is needed in the world is not of an heroic kind. Courage may be displayed in every-day life as well as on historic fields of action. The common need, is for courage to be honest, courage to resist temptation, courage to speak the truth, courage to be what we really are, and not pretend to to be what we are not, courage to live honestly within our means, and not dishonestly upon the means of others."

HABIT AND EDUCATION.

HABIT is, in a broad sense, a characteristic of all material things. The folds in your coat are habits of the texture of the cloth. Wood and iron frequently bent into special shape, tend to remain in that shape. There is a kind of inertia in matter in this respect. Comte called it the "indolence of nature." Physicists speak even of the "fatigue" of steel. All habits have a physical basis. Our mental and moral habits are based on the physiological habits of our nerve centers.

"It is not work that kills men," says Henry Ward Beecher, "it is worry. Work is healthy: you can hardly put more upon a man than he can bear. Worry is rust upon the blade. It is not the revolution that destroys the machinery, but the friction."

"You cannot dream yourself into a character; you must hammer and forge yourself one."

"The heights by great men reached and kept,
Were not attained by sudden flight;
But they, while their companions slept,
Were toiling upward in the night."

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

IN THE INTERNATIONAL CORRESPONDENCE SCHOOLS, SCRANTON, PA.

FROM MACHINIST TO DRAFTSMAN AND DESIGNER.

I have worked ever since I was twelve years of age, but today I possess a good mechanical education. I have finished the Complete Mechanical Course of The International Correspondence Schools, and have received their diploma. I have risen from an ordinary machinist to be a draftsman and designer, and now hold a responsible position with a good salary, which is largely due to the thorough course of instruction received. I am now taking the Electrical Engineering Course, and hope to rise still higher.—*Alex. McKendrick* (*C. 2452, M. E. 8369*), *Paterson, N. J.*

IS NOW A MUNICIPAL ENGINEER.

I am proud to acknowledge myself a graduate of The International Correspondence Schools. Immediately after completing my course, I applied for the position of engineer for Plymouth, Pa. The fact that I held the Schools' Diploma, obtained the position for me. After I had been working one year, the council unanimously recommended my reelection, on account of very satisfactory work. In 1898 I was elected for the same position, and also as engineer for Edwardsville. In addition to this work I am able to do considerable outside surveying, mapping, etc. As long as I live, I will endeavor to be a credit to the School to which I owe so much.—*David Thomas* (*S. M. 80, B. 228*), *Plymouth, Pa.*

ENGINEER IN CHARGE OF A LARGE PLANT.

It affords me great pleasure to say a good word for The International Correspondence Schools. I completed the Stationary Engineering Course nearly two years ago, and at once took up the Electrical Engineering Course. During this time, I have been able to accept, in succession, two positions of responsibility, neither of which I could have filled but for the instruction received from the Schools. I have advanced from running a 7″×9″ simple engine to a 400-horsepower compound-condensing engine for a street-railway plant, and the usual electrical apparatus. The Schools are doing more to elevate the standard of engineers and electricians than any other agency, and will always receive my hearty support.—*Horace A. Dodge* (*H. 1353, M. E. 1616, A. D. 147*), *Pres. Association No. 22, N. A. S. E., Rockford, Ill.*

HAS BECOME AN ELECTRICIAN AND INVENTOR.

I cannot recommend The International Correspondence Schools too highly. Since taking the Electrical Power and Lighting Course, I have become electrician for the New Union Station, St. Louis, Mo. From the knowledge gained in the Course, I have been able to invent and successfully procure patents on mechanical and electrical devices in the United States, Canada, Great Britain, Germany, and France.—*Geo. P. McDonnell* (*J. 113, H. 7665*), *St. Louis, Mo.*

FROM TRAPPER TO SUPERINTENDENT.

I have worked in and around mines for upwards of 27 years, and have advanced myself from trapper to superintendent. I supplemented my practical experience by devoting all my spare time to the study of the Complete Coal Mining Course of The International Correspondence Schools, and acquired a thorough theoretical knowledge of mining.

This knowledge has enabled me, on several occasions, to successfully meet severe tests of my ability as a surveyor. In one case I ran an entry 500 feet, almost a half circle in shape. The workmen started at each end and the connection was perfect. All my theoretical knowledge I gained through the Schools.—*James Macleery* (*C. M. 34, S. M. 120*), *East Branch, W. Va.*

CARPENTER ADVANCED TO CONTRACTOR AND BUILDER.

I take pleasure in stating that I have derived great benefit from the method of teaching, as it is thoroughly practical. The Instruction and Question Papers are clear, easily understood by any one, and most thorough. The method of instruction is satisfactory in all respects, and the work sent in undergoes such careful ex-

amination that I have been surprised at what minute mistakes receive correction. As far as I have progressed with my course, it has been very beneficial to me. I have been able to advance myself from a carpenter to a contractor and builder, and expect eventually to become an architect, for all of which I credit the Schools.—*John J. Wollett* (*A. 172*), *Jefferson, Wis.*

CHIEF MACHINIST ON A WARSHIP.

To the man who works from 10 to 14 hours a day, and whose means is limited to the small pay received by the engineer at the bottom of the ladder, I have this to say regarding The International Correspondence Schools, of Scranton, Pa. I believe it is just the thing necessary to decrease his hours of labor and increase his salary, since the man who has the best knowledge of engineering gets ahead the fastest. I was a little skeptical at first regarding the correspondence system of instruction, but the manner in which things were explained was a revelation to me. I found the knowledge gained in the Schools of great service to me in obtaining and filling the responsible position of Chief

Machinist on one of Uncle Sam's ships during our war with Spain. Somebody hit the spike in the right place when he said, "To earn more, learn more."—*H. D. Hill* (*H. 7860*), *Cleveland, Ohio.*

HIS SALARY RAISED—1,000 OTHERS REDUCED.

The benefits derived from my Complete Mechanical Course in the Schools are many. I commenced receiving extra pay for drawings soon after completing the subject of Mechanical Drawing. During the hard times of 1895–96 my wages, as engine runner, were raised, while those of every other employe, to the number of 1,000 men, from superintendent to the boy who gathered the time books for the

different departments, were cut to a lower scale. I am now my own employer.—*Levi C. Beardsley* (*C. 287*), *Garden, Mich.*

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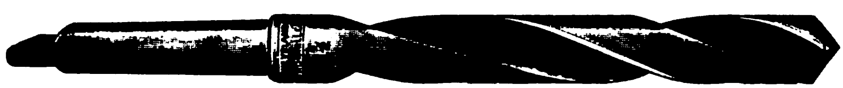

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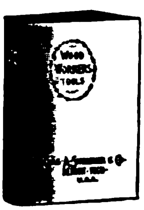

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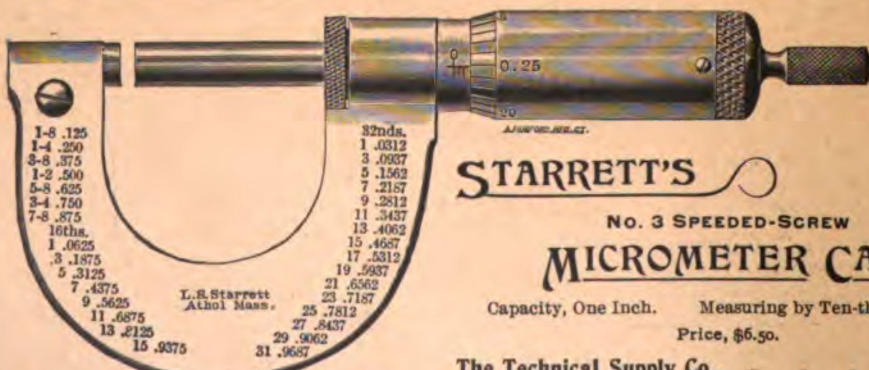

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THE MECHANIC ARTS MAGAZINE.

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THE TESTING OF STEEL.

C. P. Turner.

IMPORTANCE OF SYSTEMATIC TESTS—PRACTICAL METHODS OF TESTING—TYPES OF TESTING MACHINES—PREPARATION OF SPECIMENS—HIGH AND LOW CARBON STEELS.

IRON is by far the most valuable material used in modern engineering operations, and, of the many forms in which it is now employed, the most important and interesting are the products of those wonderful processes, the Bessemer and the open-hearth, or Siemens-Martin, which are classed under the general name of steel. The rapid development of the methods by which steel has been brought to its present great importance in our every-day life is due in great measure to the systematic methods of testing that have been applied to the study of the effects of different methods of manufacture on its physical properties.

The first and, in many respects, the most important test to which steel is subjected is a chemical analysis. It has been found that the presence of certain chemical elements, of which carbon, the principal element in the composition of coal, is the most important, is essential to the production of good steel, and that its strength, hardness, ductility, and malleability can be varied through a wide range by varying the proportion of these elements. There are other elements, notably sulphur and phosphorus, whose presence in steel is objectionable, their effects being almost universally bad. Unfortunately, these undesirable elements have a great liking for the society of iron; they are generally found in the ores and fuel used in its manufacture, and it is a difficult and expensive process to remove them. Experience shows that, for a given grade of steel, a certain proportion of carbon is required, while the allowable percentages of the objectionable elements must not be exceeded. These considerations show the importance of the chemical analysis as a preliminary, by means of which the probable qualities of the steel can be determined; in fact, if we have given a steel of satisfactory chemical composition, definite physical properties are assured if the processes of casting, heating, rolling, forging, and annealing are properly carried out. If these processes could always be thoroughly regulated, no purely physical tests would be required for those grades of steel in which the relation between the chemical composition and physical properties has been definitely established. Unfortunately, however, the different processes employed in developing the finished bridge bar, piston rod, or propeller shaft from the crude molten metal turned out by the Bessemer converter or the open-hearth furnace cannot always be so controlled as to secure perfectly uniform results; on account of this uncertainty, physical tests are generally demanded for all steel to be used in important work, no matter how satisfactory the chemical analysis may be.

Physical tests are of two general classes, which, however, are often so closely allied that each serves the purpose of the other. The first class, which may be called practical, consists of tests made solely for the purpose of determining the suitability of a given piece or grade of material for some particular purpose; the second is more especially devoted to the study of the effects of differences in chemical composition, or methods of manufacture, on the properties of the material, and is more scientific in its purpose. These two classes of tests are often

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combined in one operation; in many cases, a test whose primary object is to determine the strength of a single specimen and its adaptability for some special purpose, is made with so much care, and all the conditions are so thoroughly noted, as to make the record of the results valuable for purposes of later scientific study. It is not the purpose of this article, however, to deal so much with the scientific branch of the subject as it is to describe the general methods employed in practical commercial testing and the significance of the different phenomena developed by these methods.

The first requisite of a material to be used in engineering operations is that property which we call *strength*—that is, the ability to resist the action of forces; the first test demanded is, therefore, one which will give us a measure of the strength. There are, however, several other properties, notably ductility, malleability, and hardness, which, in the case of steel, are of as much importance as its strength; the tests must therefore be so conducted as to furnish reliable information regarding these secondary properties. Steel is also called on to resist the action of forces in a number of different ways; it may be subjected to a direct pull, which produces what is known as a *tensile stress;* again, it may be acted on by a force that tends to crush or *compress* it, or it may be subjected to a *bending*, a *shearing*, or a *twisting* stress. In many cases there are combinations of several of these stresses, in addition to which the metal is called on to resist the effects of abrasion or wear.

When used for the journals of machinery, steel must combine a reasonable degree of hardness with the strength and ductility that will enable it to resist bending, torsion, and shock; in boiler plates and rivets, the ability to withstand a great amount of cutting, bending, hammering, and shock, together with the effects of sudden changes of temperature, are imperative. Many of these properties are conflicting in their nature; great strength and hardness can be obtained only at the expense of ductility and the ability to resist shock and sudden changes of temperature.

Experience shows that the most satisfactory service for a given class of work is obtained by the use of a steel in which a certain relation between these conflicting properties is maintained, those properties which are of minor importance being sacrificed for the sake of the others.

It is manifestly impracticable to subject a specimen of each lot of steel intended for some particular class of work to an exhaustive test which will subject it to just that set of conditions under which the material is to be used; such a test of steel for car axles would require that an axle from each heat be put into a machine that would subject it to the same combination of bending stresses, shocks, and journal wear as that to which the axles are to be subjected in practice, and that these conditions be maintained for a period which would show the length of life of the axle. From a commercial point of view such a test is impracticable, perfect as it may appear in theory; it is, therefore, necessary to resort to some simpler method for all commercial purposes. A piece that represents the average quality of the steel from which the axles are to be made is subjected to a few simple tests that will reveal its most important physical properties; the results of these tests, together with all available data regarding chemical composition and processes employed in the manufacture of the axle, are carefully recorded; finally, a careful record is made of the performance of the axles in actual service.

From such a set of tests and records, carried on through a term of years, steel makers and the users of car axles are enabled to select the particular combination of chemical and physical properties that gives the most satisfactory results for that particular class of work. A similar process is employed with the material to be used for boiler plate, rivets, bridge bars, crank-shafts, springs, etc.; and a careful study of the records of these tests and observations enables us to use steel with much more satisfactory results than would otherwise be possible. The old prejudice against the new material, which was the result of an unfortunate choice of the grade, due in some cases to a mistaken idea as to what properties were desirable, but more often to complete ignorance of the wonderful range and conflicting nature of the properties that were all covered by the very indefinite name of steel, is now fast disappearing.

The most satisfactory method that has yet been devised for studying the physical properties of steel for structural purposes and machinery is that in which the effects on a convenient specimen, of loads which are gradually increased until the specimen finally breaks, are carefully determined. The simplest method of making such a test is to load the specimen with known weights and observe the effects produced as the load is gradually increased. This method, however,

is too slow and cumbersome to be commercially practicable; the loads demanded for even the simplest commercial tests are seldom less than 50,000 pounds, and loads of 100,000 and 200,000 pounds are common. The direct application of weights is therefore impracticable in most cases, and various machines have been devised by means of which any load between the smallest that will perceptibly affect the specimen and one sufficiently large to break it may be quickly and easily applied and accurately weighed.

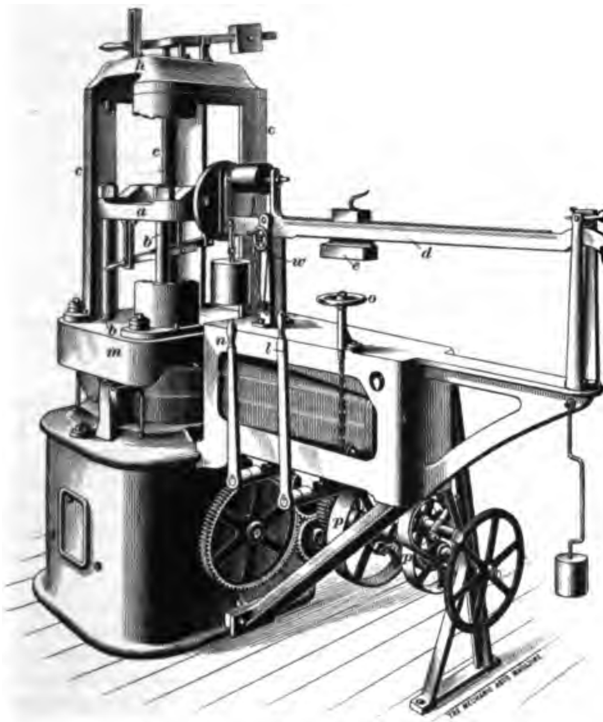


FIG. 1.

Two general classes of these machines have been used. In the first, the specimen is loaded by means of a hydrostatic press; in the second, a screw, generally in combination with a train of gearing, is used. In each of these classes the load is applied to the specimen in such a way that it acts through some simple form of weighing machine that enables the operator to see at once just what force is being applied.

With the exception of the Emery testing machine, which is the most ingenious and accurate device for weighing heavy loads that has yet been invented, machines of the former class are now but little used; they have a number of disadvantages, among which are the difficulty of keeping the press filled with a suitable liquid, the difficulty in keeping the packing of the plungers in good order, and the intermittent manner in which the load is applied, by means of the strokes of the pump.

The general features of the type of screw machine now most commonly used in this country for making tests of iron and steel are shown in Figs. 1 and 2. Either of these machines may be readily used for subjecting a suitable specimen to any one of three types of stresses, direct tension, direct compression, and transverse, or bending, and the load in each case can be accurately weighed.

Fig. 1 is a machine built by Tinius Olsen, and that shown in Fig. 2 is made by Riehlé Bros. The general principles are the same in each, and their operation will be readily understood from the following description: A head *a* may be moved vertically by means of the screws *b*, of which there are four in the Olsen and two in the Riehlé machine. The screws receive their motion from any convenient source of power, through belts on the pulleys *p*, *p*; these pulleys are loose on their shafts, and a crossed belt on one and an open belt on the other gives them rotation in opposite directions. The lever *l* operates friction clutches that connect either pulley with its shaft, the motion being transmitted through the gearing to the screws so as to raise or lower the head *a*. By means of the lever *n* and the hand wheel *o*, different combinations of the gearing can be effected so as to give different speeds to the head *a* for different classes of tests. The head *h* is supported by the columns *c*, *c*, which stand on the platform *m* of a large scale whose weighing beam is shown at *d*. This beam carries a poise *e* that moves on rollers along the beam; a hand wheel *w* operates a screw or chain that lies along the top of the beam and moves the poise without disturbing its effect on the beam, thus enabling the operator to move the poise slowly out along the beam as the load increases, and see at all times just what load is being applied. In some cases

the poise is moved automatically by means of gearing that is set in operation by electrical connections formed by the beam as it rises or falls.

To make a tensile test, the specimen is held between two pairs of jaws, one in each of the heads *a* and *h*, as shown at *s* in Fig. 2. As the head *a* is drawn down by the screws, the pull on the specimen is transmitted to the head *h* and thus to the platform of the weighing scales.

For a compression test the specimen rests on the platform *m* and the load is applied by drawing the head *a* down upon it.

A transverse, or bending, test is made by

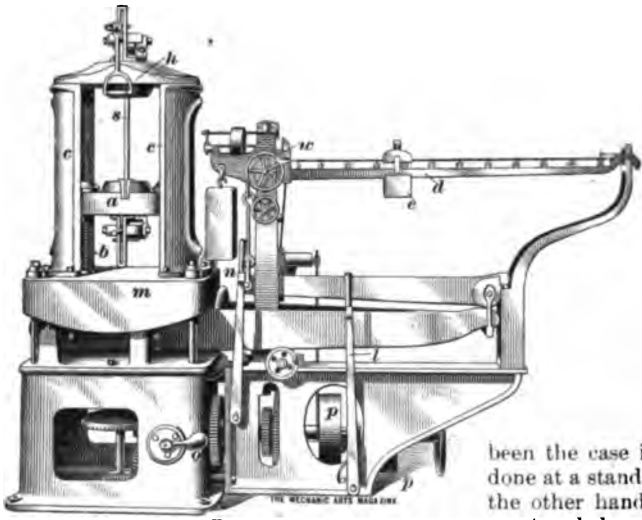


FIG. 2.

placing the specimen on two supports carried by a heavy frame that rests on the platform of the scales; the load is applied by means of a projection on the under side of the head *a*, which presses on the center of the specimen as the head is drawn down.

Although these machines may be readily used for testing specimens under compressive and bending stresses and are often so used in experimental and scientific work, experience shows that the tensile test gives the simplest and most reliable means of determining those properties that interest the engineer.

There are two tensile tests to which a heat of steel is usually subjected at the mills. The first, commonly called the heat test, is made on a specimen that is prepared in such a manner as to show, as clearly as possible, the general properties of the steel and its fitness for the purpose for which it was made. Upon the results of this test the makers base the treatment of the steel during later operations in the mill and forge. Considerable care is taken to secure an average specimen of the steel from the heat, and to carry out the operations of heating, forging, rolling, and final cooling in such a manner as to insure results that are as nearly uniform as possible, apparently slight and unimportant differences in the methods of preparing these specimens often producing results that are very misleading. For example, if the specimen is rolled when the steel is very hot, it is much weaker, softer, and more ductile than would have

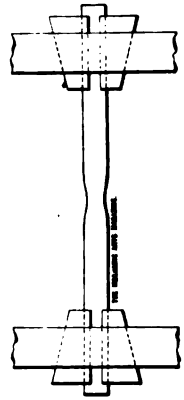


FIG. 3

been the case if the work upon it had been done at a standard normal temperature; on the other hand, working the steel at a temperature below the standard makes the specimen stronger and harder, but more brittle.

The usual dimensions of these standard test bars are $\frac{3}{4}$ inch in diameter and about 20 inches long. Before the test, the diameter is measured by a micrometer caliper to the nearest $\frac{1}{1000}$ inch, and, by light scribe or center-punch marks, a length of about 12 inches near the middle is divided into spaces 1 inch long; from these measurements and marks the area of the section of the specimen is calculated and the amount of stretch under the action of the load is measured.

In the testing machine the behavior of the different grades of steel, as the load is gradually increased, varies greatly and forms a valuable index to the character of the material. High carbon steels, such as are used in the manufacture of springs, stretch but little; the movement of the poise shows a steady and comparatively uniform increase in the load from the beginning of the test until the specimen finally breaks, about the only

visible change in the appearance of the specimen, before the break occurs, being a sudden loosening of the scale under a load about half as great as that under which it breaks. With the softer steels, however, the action is very different. The load, during the beginning of the test increases at a nearly uniform rate, while the specimen, as before, stretches very little; but this period is much shorter than it was with the hard steel—a point is soon reached where the scale begins to loosen rapidly, and the specimen seems to undergo a wonderful change and to take on properties quite different from those we generally ascribe to steel. It now stretches rapidly for a few seconds with no increase in the load indicated by the poise, and seems to be on the verge of failing entirely. After a few seconds, however, it apparently recovers its strength to a certain degree, and the load gradually increases as the specimen is pulled, until a maximum is finally reached, which is the greatest load the specimen will carry. Unlike the hard steel, however, it does not break when the maximum load is reached, but continues to stretch under a decreasing load. During this period there is a great reduction in the sectional area of the specimen at a point generally about half way between the grips, as shown in Fig. 3, the area at the point of fracture being much less than the original area of the bar.

(*To be Continued.*)

IN THE WORKSHOP.

(*Continued from the April, 1899, Number.*)

H. Rolfe.

SHALLOW REASONING IN THE SHOPS; THE SAME THING IS MET WITH IN HIGHER PLACES ALSO—EVILS OF "SMALL TUBES AND PLENTY OF 'EM"—A CASE IN POINT.

THERE is, in the engineering trade, a class of people that rejoice in calling themselves "practical men," and that are always on the lookout for holes and weak places in the armor of certain others whom they stigmatize as "theoretical men." We will not now pause to inquire, as Macaulay would say, what special attributes the first-named men lay claim to when they dub themselves "practical," though we *have* seen it stated (on the authority of the London "Engineer") that the practical man is for the most part simply a reproducer of other peoples' blunders. Anyway, one of these men tackled the writer in his early apprentice days with a problem that was evidently relied upon to be a "floorer," and to knock the stuffing out of theory once for all. In this, it may be remarked, the writer simply shared the ordeal of every apprentice that was passed through this man's hands; any one that had the audacity to be able to figure out the strength of a ¾-inch bolt, he immediately classed as a "theory man"; nor was this fellow by any means a solitary specimen of the middle-aged British workman of those days. Well, one meal hour he assumed a didactic air and spake thus: "If one man can build a certain wall in a day, two men working at the same rate will do it in half a day, won't they?"

I assented to this remarkable proposition.

"And twenty-four will do it in an hour?"

I offered no objection.

"And forty-eight in half an hour, and ninety-six in a quarter of an hour, and fourteen hundred and forty in a minute?"

Here he paused and looked around triumphantly at his supporters.

"Well," I said, "what about it?"

"What abart it? (He was a cockney.) Is there any sense in it? Doesn't it show that mathematics is all wrong? You bloomin' raw apprentices fresh from school thinks yer knows it all, but yer don't, not by a long chalk. Talk ter me o' the hinfallerbility o' figgers! *Could* a thousand men put that there wall up in a minute? Why, they couldn't bloomin' well get near it."

Of course, any defense of the above argument is unnecessary in an enlightened community, but let us not too severely condemn that man. A very similar line of reasoning is often unconsciously adopted by engineers of a *higher* grade, aye, and by good ones, too, of all men. They get hold of an idea that is right enough in itself, and then, in carrying it out, make the mistake of "overdoing it." We append an instance that occurs to us now, and doubtless many of our readers will, on their minds being thus jogged, call up other and similar cases.

The mistake has been made, before today, of using too small tubes in locomotive boilers. The shallow, unthinking argument of the offenders in this direction is doubtless somewhat thus: "What we want is steam. To get it we must have heating surface. Now, *tubes* give us heating surface; *ergo*, the more of them we have the better."

This is a glaring case of overdoing it. Up to a certain point the argument is all right. Thus, suppose we start out with one tube, as in Fig. 1 (Stephenson's locomotive of 1814 had one 20-inch flue in a 34-inch barrel); we shall get a certain amount of heating surface, namely, the internal surface *s*; but think of the waste of heat! Only the layer of hot gas near the inner surface of the tube will give up any large proportion of its caloric; all the inner body, or *core*, of heated gas will pass through and out at the other end without coming in contact with the tube, and, therefore, without getting a chance to give up its heat. The first step, then, is to lessen this core of unutilized gases, which can best be done by reducing the diameter of the tube and putting in several of them, say five, as in Fig. 2. From this to the multitubular boiler as we now have it, was clear running, gradually reducing the diameter of the tubes and adding to their number, thus reducing the total volume of wasted hot gases and increasing the efficiency of the boiler. Stephenson's "Rocket" of 1829 had twenty-five 3-inch tubes in a 40-inch barrel; this and the turning of the exhaust into the chimney were regarded as mainly responsible for the success of his engine, and constituted perhaps the greatest advance ever made in locomotive design. Fig. 3 shows how we pack tubes in nowadays.

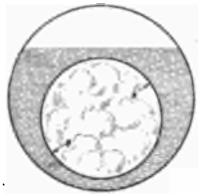


FIG. 1.

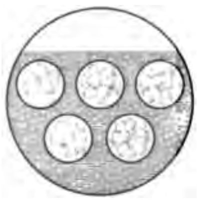


FIG. 2.

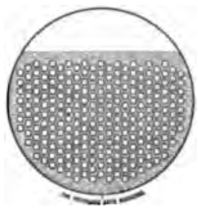


FIG. 3.

Up to a certain point, it is all right to thus decrease the diameter and increase the number of tubes; but it is possible to go too far, and then it shows bad reasoning. We will instance a case: The locomotive superintendent under whom the writer served his time, began at a certain period of his career to cram the boilers full of small tubes, in the fond hope that he was thus usefully increasing the heating surface. It was like this: A demand had arisen for more powerful engines to run a certain very heavy fast train. The company disdained to use a pilot to get a good start, so the difficulty had to be gotten over in some other way. The superintendent built an engine that was altogether heavier than those previously in use, and put in larger cylinders. He had the good sense to know, however, that large cylinders and great adhesive force are of little use unless the former can be provided with a plentiful supply of steam. So he went in for a good liberal heating surface. He got all the surface he could in the firebox, which, however, he could not make more than about 6 feet long inside, as it had to go in between the middle and the rear axles. The engine being inside-connected, there was the back end of the main rod that had to clear the stay in the front of the firebox; this stay was ⅞ inch thick and itself had to clear the outer shell of the firebox—the staybolt heads at that; thus, the box was a good deal shorter than it would have been with an outside-connected engine. It was necessary to keep down the total length of the engine—not to avoid a too long side rod, for the engine was front-coupled, but to keep down the total wheel base, which was rigid throughout, no truck being used. Of course, the box could have been lifted up above the rear axle, but that would have perched the boiler far higher than the old-fashioned ideas then in vogue would have allowed; they believed, in those days, that a top-heavy engine was unsafe.

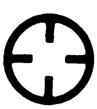


FIG. 4.

The only way out of it was to get more heating surface in the tubes, and this meant more tubes, and therefore a bigger barrel. But a bigger barrel was not permissible, because then the boiler would have to set higher in order to get it between the wheels. The only alternative was to use smaller tubes and to put them closer together, and the superintendent did both; he cut down the diameter from 1¾ inches to 1½ inches and

squeezed in an extra hundred of them, the final result being 333 tubes of 1½-inch diameter; and he made them of steel instead of brass, so as to save space by using thinner metal. He thus obtained—on paper, at any rate—an additional 300 square feet of heating surface. But it availed him nothing, and the following arguments will show why: The engine had more heating surface all right enough, but

1. The tubes, being so small, soon choked up; the more especially as the engines were using soft coal and had no draft appliances.

2. The tubes being packed so closely together—there was only about ⅜-inch space between them—made it harder for the steam to rise to the surface and for the water to circulate properly.

3. The tubes scaled up badly, which made matters still worse. This particular road had to use water containing a great deal of lime, for the district wherein it operated "stood on the chalk," which phrase refers to its being on the 900-foot bed of chalk that runs diagonally across England, from the southeast coast up into Yorkshire—the same that gives England the "chalk-white cliffs of Dover" that some poet who never had boilers to look after sang about. As a result, the tubes soon had about $\frac{3}{16}$ inch of scale on them, and then there was precious little water or steam space left, and, of course, the few lowest rows were soon scaled up solid.

The first thing that a fireman did at the end of a run, even if only 50 miles, was to rush around to the front end and sweep out as many of the 333 tubes that a wise and foreseeing superintendent had provided for his delectation and delight as the time at his disposal would allow.

In due time, however, the superintendent died and a man from another road reigned in his stead, and there was an early return to 1¾-inch tubes properly spaced.

We may regard the foregoing, then, as one instance of "overdoing it."

One of the best features we have seen in the construction of American locomotives is the large-sized tubes that are used. But, while we regard a 2-inch tube as a good thing in general, still there can be little objection to the 1¾-inch tubes, provided the draft appliances are properly adjusted so as to militate equally against any of them getting choked up. In fact, we think it is the *close packing* of the smaller tubes, rather than the small diameter of the tubes themselves, that causes the trouble. The point is this: whereas, to impart the generated heat to the water, heated metal surface is the desideratum; still we must make sure that a large body of water surrounds each portion of the metal, and also that there is good circulation, so that not only may the steam readily leave the surface of the metal upon which it is formed, and rise into the steam space, but also that its place may be speedily taken by cooler water. If the tubes are packed too closely, these aims are thwarted, and if the water is bad, some of the space it should occupy is soon appropriated by scale, and so things are made worse, and, as the lower spaces fill up, the circulation is still further impaired.

Another item, which again shows lack of thought, is carrying the rows of tubes too low. Although all surfaces get their share of the lime and sediment in the water, yet the greater part of this sediment settles to the bottom, so that in a short time the two or three lowest rows are completely covered and rendered useless for heating purposes, when, being cut off from the water, they burn out. Besides, it is better for cleaning out purposes to omit them.

We have been saying that up to a certain point, the smaller the tubes the better, because the smaller the columns into which the hot gases are divided, and therefore the smaller the internal cores of untouched heat become. In Europe, they have gotten over this difficulty in a rather neat way, by making the tubes ribbed, as in Fig. 4. The ribs *dip into* the central core of hot gas and take up the heat in a very effective manner. They are necessarily a little more difficult to keep clean, but this has been gotten over. These tubes are also, we believe, made with a slight twist in them, to prevent the hot gas from passing clear through in a straight line; this would seem to give every particle a better chance of coming in contact with the cool metal.

We may remark that we have shown the tubes as in Fig. 3 in deference to general practice, though our personal preference inclines to another arrangement, which will be discussed in a future article dealing with the general question of tubes. The arrangement we allude to may be described in words thus: Take any tube as center and describe a circle with a diameter equal to the outside diameter of tube plus the clearance between them. Then divide this circle into 6 equal parts, setting a tube on each division point as before, but placing three tubes on the horizontal diameter instead of on the vertical one, as in Fig. 3.

(*To be Continued.*)

SLIDING FRICTION.

(Continued from the April, 1899, Number.)

G. Herbert Follows.

FRICTIONAL WORK NOT SUBJECT TO THE LAWS GOVERNING FRICTIONAL RESISTANCES—LOCATING FRICTION IN MACHINERY—INFLUENCE ON DESIGN AND EFFICIENCY.

SO FAR, we have considered only *one* way of overcoming sliding friction, namely, by an equal and opposite force producing direct sliding of one body over another. But in machines it is comparatively seldom that one part slides bodily over another; it is far more common for one part to *rotate* in another, as, for instance, a shaft in a cylindrical bearing, a screw in a nut, a spindle in a pivot bearing. The same simple laws, however, hold good in every case, but in order to apply them intelligently it is necessary to fully appreciate the fact that when a frictional resistance is overcome, *work* is done. Thus, if the resistance is 5 pounds, and it is overcome through a distance of 10 feet, 50 foot-pounds of work is done; and it makes no difference whether, to overcome the resistance, a leverage of 1,000, or a leverage of 10, or no leverage at all, is used, *the work done is the same.*

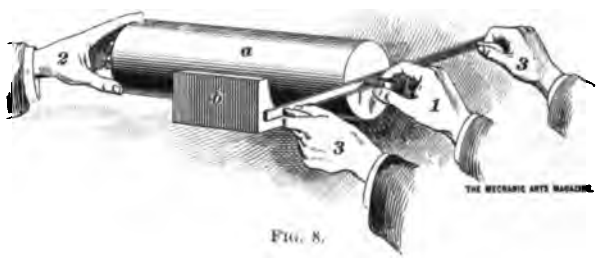


FIG. 8.

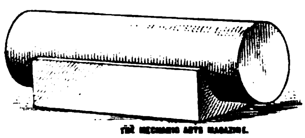


FIG. 9.

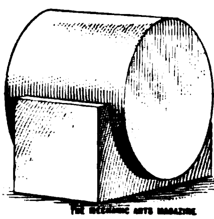


FIG. 10.

In Fig. 8 there are indicated three different ways of rotating the short cylindrical shaft *a* in the bearing *b*; supposing the weight of the shaft to be 10 pounds, its circumference 1 foot, and the coefficient of friction .10, then the work done during one revolution of the shaft, no matter which of the three ways of rotating it is used, is $10 \times .10 \times 1 = 1$ foot-pound. Of course, it is very much *easier* to rotate the shaft by means of the long handle than by the two projecting pins, just as it is easier for a man to lift a 10-pound weight 100 feet than to lift a 1,000-pound weight 1 foot—but the actual work done is the same; in one case we have a small force acting through a long distance, and in the other a much larger force acting through a short distance, the work done in the two cases, however, being identical.

And now, as a practical test of the second law, suppose we double the area of the bearing in Fig. 8. There are evidently two ways of doing this: by doubling its length, as in Fig. 9, and by doubling its diameter (and with it the diameter of the shaft), as in Fig. 10. Taking the longer bearing first, we know that the frictional *resistance* is the same as before, because friction is independent of the areas of the surfaces in contact; and it is evident that the *work done* during one revolution is also the same as before, because, the diameter being the same, the distance through which the resistance is overcome is the same. So far, then, we find nothing that conflicts with the proven laws. But with the bearing and shaft of larger diameter, though we know again that the frictional resistance is unchanged (assuming the weight of the shaft to be still 10 pounds), we find that, during a revolution, this resistance is overcome through double the distance, and that, therefore, double the amount of work is done.

Now, the efficiency of a machine depends, not upon the frictional *resistances* within it, but upon the amount of *work* done in *overcoming* the resistances; so that where increasing the areas of two sliding surfaces also increases the distance they have to slide, the efficiency of the machine is reduced, because such an increase of area, though it leaves the resistance unchanged, adds to the wasteful work done. Although, therefore, it is true that frictional

resistance is independent of the areas of the surfaces in contact, it is *not* true that frictional *work* is similarly independent.

It is precisely the same with a vertical shaft in a footstep bearing, as in Fig. 11, though it is not as evident, on the face of it, how to determine the actual amount of work done during a revolution, because the distance through which the resistance has to be overcome varies from zero at the center of the bearing, to a maximum at the outer edge; thus, if the shaft were pointed, as at (a), Fig. 12, the work done during a revolution would be zero, because the distance through which the resistance is overcome is zero, and resistance multiplied by $0 = 0 =$ work done; if, instead, it were cupped out, as at (b), the work would equal the frictional resistance multiplied by the circumference of the shaft. It is evident, however, that, with the flat bearing of Fig. 11, the pressure between the shaft and the bearing, and, therefore, the resistance to rotation, is uniformly distributed over the surfaces in contact, and not concentrated either at the center or at the outer edge. This suggests that, for the sake of convenience in figuring, we may consider the pressure as concentrated, as at (c), Fig. 12, at a circumference whose length is equal to the *average* distance moved through by the end surface of the shaft against the distributed resistance.

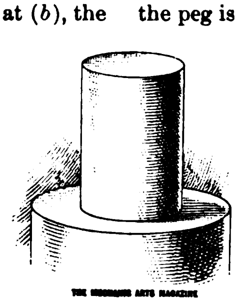
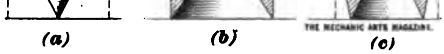


FIG. 11.



(a) (b) (c)

FIG. 12.

This average distance, very approximately, is the circumference of the circle whose diameter is $\frac{7}{10}$ of the outside diameter of the shaft; if, then, for example, the shaft is 4 inches in diameter and weighs 100 pounds, and the coefficient of friction is .08, we have a resistance of $100 \times .08 = 8$ pounds, which, during one revolution, is overcome through a distance of $4 \times \frac{7}{10} \times 3.1416 = 8.8$ inches, and thus the work done is $\frac{8 \times 8.8}{12} = 5.9$ foot-pounds.

This reminds us of the good old question: "If it is true that friction is independent of the areas of the surfaces in contact, why does a top spin longer on a sharp peg than on a dull one?" The answer is: a rotating body—and, therefore, a spinning top—possesses kinetic energy, or stored-up work, as it is sometimes called. This energy, the spinning top gradually spends in overcoming the frictional resistance between itself and the surface upon which it is spinning. (We purposely leave the air friction out of consideration, because the degree of sharpness of the peg makes no appreciable change in it.) Now, it will at once be seen that the greater the diameter of the peg the greater the distance per revolution through which the resistance must be overcome, and, therefore, the more work spent by the top. The case is exactly analogous to that of the shaft in the footstep bearing; if the diameter of the peg is doubled, the top will spin just half as long, because during each revolution it has to do just twice as much work; and if the diameter of the peg is reduced one-half, the top will spin just twice as long, because during each revolution it has to do only half as much work.

If, now, we pause for a few moments and review what has thus far been said, we find that we have proved that:

1. Frictional resistance varies directly as the pressure between the surfaces in contact.
2. Frictional resistance is independent of the areas of the surfaces in contact.
3. The resistance due to each pair of surfaces in contact must be considered separately.
4. It is necessary to distinguish clearly between frictional *resistance* and frictional *work*, because the work varies with the distance through which the resistance has to be overcome.

And this is enough to enable us to solve any simple problem concerning the efficiency of a machine.

Returning, therefore, to the winch of Fig. 1 (see April number), and assuming that the reader is able to resolve the various forces and thus determine the pressures between the several pairs of surfaces in contact, we first determine what pressure 10 pounds at the crank-handle produces at each bearing. Then, taking each shaft separately, and ascertaining through what distance its resistance has to be

overcome in one revolution of the crank, we multiply each resistance by its distance, add together the amounts thus found, and thus obtain the total work done in overcoming frictional resistances within the winch. (In the following general solution, all attempt at positive figuring is purposely avoided, and the sliding friction between the several pairs of gears, as well as the rope friction, is neglected; in actual practice, these are, of course, taken into account; it is necessary, however, to omit them here, for the sake of clearness and simplicity.) The work done at the crank (in other words, the *input* of work) is $\frac{10 \times 15 \times 2 \times 3.1416}{12} = 78.54$ foot-pounds; if, from this, we subtract the total frictional work (which we will assume was found to be 25.54 foot-pounds) we have the useful work, or *output*, namely, 53 foot-pounds. Next, taking the gear ratio of 150, we ascertain the distance through which the unknown weight is raised during one revolution of the crank; thus, the crank moves through 3.1416 times 2 feet 6 inches, or 7.854 feet; dividing this by 150 gives the distance through which the weight is raised, namely, .05236 of a foot. Remembering that the output of work is 53 foot-pounds, we divide it by this distance .05236, and thus get the weight that 10 pounds at the crank-handle will lift, namely, 1,012 pounds.

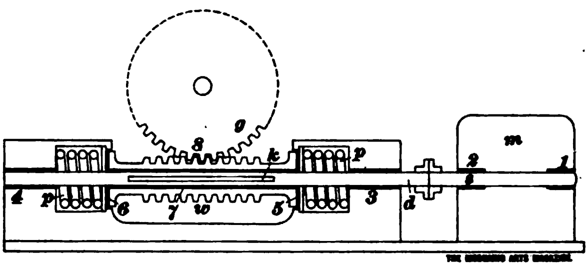


FIG. 13.

Fig. 13 is a diagrammatic representation of a driving mechanism for an electric coal shovel designed by the writer some years ago, which illustrates in an excellent manner the practical application of the laws under consideration; *m* is the electric motor, *s* the motor shaft, *d* the driving shaft, and *w* a worm engaging with the worm-wheel *g*. The worm is driven by a feather key *k*, which leaves it free to slide lengthwise in either direction whenever the end thrust upon it exceeds the resistance offered by either of the compressed helical springs *p*. The digging part of the machine was so designed that when the shovel either closed or opened wide, the worm-wheel instantly stopped rotating and the electric current was cut off, but the armature and other parts were left rotating at a speed of 750 revolutions a minute. At this speed, the rotating parts, which weighed in all over 500 pounds, were possessed of considerable stored-up energy that it was necessary quickly, yet without shock, to absorb; it was for this reason that the worm was left free to move lengthwise, against the two helical springs, so that the rotating parts might spend their stored-up energy in overcoming frictional resistances and in further compressing one of the springs. In the diagram, the several pairs of surfaces in contact are indicated by heavy lines numbered *1*, *2*, *3*, etc.; at *1* and *2* we have cylindrical bearings for the armature shaft; at *3* and *4*, cylindrical bearings for the direct-coupled driving shaft; at *5* and *6*, end-thrust bearings for the worm; at *7*, the worm in direct sliding contact with the driving shaft; and at *8*, the worm-thread in sliding contact with the teeth of the worm-wheel. During a revolution of the armature, each of these pairs of surfaces slides a certain distance, against a certain resistance due to a certain pressure and a certain coefficient of friction, all of which had to be carefully figured before it was possible to assert that using a spring of certain dimensions, the armature would come to rest after making 2½ revolutions, which was the greatest number the design would permit.

Before concluding, suppose we take a simple example and work it out from beginning to end. In Fig. 14 we have a diagram representing a means of raising a weight. Using both hands on the double crank, what force will raise 5,000 pounds?

The sizes of the parts are clearly shown on the drawing, and the several pairs of surfaces in sliding contact are indicated, as before, by heavy lines. At *1* and *2* we have direct sliding contact between the weight and the vertical guides; at *3*, end rotary contact between the screw and the weight; and at *4*, end rotary contact between the screw thread and the nut. (Note that we say screw *thread* and not *threads*; a screw thread is continuous, and, therefore, between a nut and a screw there is but one pair of surfaces in contact, no matter how many threads to the

inch the screw may have or how long the nut may be.) Now, it is evident that the useful work done, or output, during one revolution of the crank, is equal to the weight multiplied by the vertical distance through which it is raised, or $5{,}000 \times .25 = 1{,}250$ inch-pounds. Neglecting friction, the force required at the crank is 1,250 divided by the circumference of the crank-circle in inches, or $\frac{1{,}250}{30 \times 3.1416} =$ about 13 pounds—6.5 pounds at each handle. We shall soon see that in a design of this kind friction is a serious item, and that it greatly reduces the efficiency of the machine, which under the above conditions would of course be 100 per cent.

In order to ascertain the amount of work done in overcoming the frictional resistances, we have first to assume a coefficient of friction for the several pairs of surfaces in contact; here we have to do a little guessing, making use of whatever judgment we may possess, and basing our guess on past experience, aided by the various published tables of coefficients. Suppose we take .08 as the coefficient for all the surfaces. As already pointed out, there are three separate and distinct pairs of surfaces in contact, *1* and *2* (taken as one pair), *3*, and *4*. To obtain the resistance due to each, we must ascertain the pressure between each pair and multiply by the coefficient .08. Now, the pressure at the guides is due to the resistance to rotation at *3*, so we must first find out what this resistance is. The pressure at *3* is 5,000 pounds, and the resistance is therefore $5{,}000 \times .08 = 400$ pounds; this may be considered as concentrated at a circumference whose diameter is $\frac{7}{10}$ of the diameter of the end of the screw, or 2 inches, as shown, when it produces at the guides, which are 12 inches apart, a pressure of $\frac{400}{6} = 70$ pounds, nearly, which produces a resistance of 70

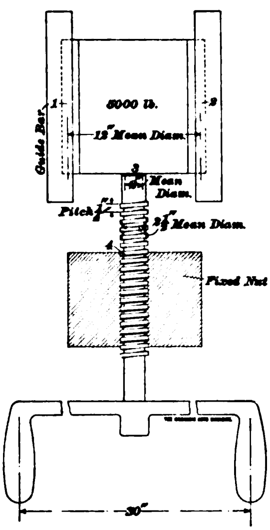


FIG. 14.

$\times .08 = 5.6$, say, 6 pounds. Theoretically, this 6 pounds should, before going further, be added to the 5,000 pounds of downward pressure; but, in actual practice, to do so would be considered a rather foolish attempt at impossible exactness (for it must not be forgotten that the coefficient, upon which all the results depend, is, and can only be, an approximation); however, as this is an assumed case, and we wish to show every effect of sliding friction on the efficiency of the machine, we will take it into account. In overcoming this 6 pounds (which it will be understood is divided equally between the two sides of the guide) the amount of work done during one revolution is

$6 \times .25 = 1.5$ inch-pounds. (1)

At *3* we now have a resistance due to a pressure of 5,006 pounds, and therefore equal to $5{,}006 \times .08 = 400.5$ pounds. This resistance has to be overcome, during one revolution of the crank, through a distance of $2 \times 3.1416 = 6.28$ in.; the work done, therefore, is

$400.5 \times 6.28 = 2{,}515$ in.-lb. (2)

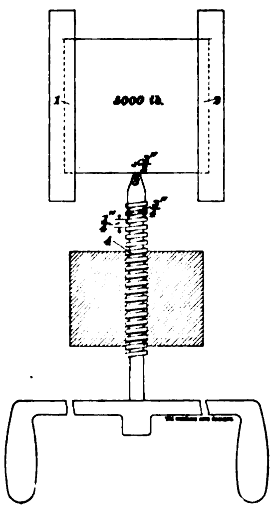


FIG. 15.

At *4*, that is, between the under surface of the thread of the screw and the upper surface of the thread in the nut, there is the same pressure, and therefore the same resistance as at *3*, namely 400.5 pounds; but the mean diameter of the thrust surface of the screw thread being 2.5 inches, this resistance has to be overcome through $2.5 \times 3.1416 = 7.85$ inches; the work done at *4* during one revolution, therefore, is

$400.5 \times 7.85 = 3{,}144$ inch-pounds. (3)

Adding (1), (2), and (3) together, we get the total amount of work done in overcoming frictional resistances, namely, $1.5 + 2{,}515 + 3{,}144 = 5{,}660$ inch-pounds (neglecting the odd half-pound); this we may call *wasteful* work, and by adding it to the *useful* work we obtain the *total* work, namely, $5{,}660 + 1{,}250 = 6{,}910$ inch-pounds.

Now, this total work done is necessarily

equal to the total *input;* but we know that the input is also equal to the force at the crank multiplied by the circumference of the crank-circle in inches, which is $30 \times 3.1416 = 94.25$ inches; therefore, the force at the crank is $\frac{6,910}{94.25} = 73$ pounds, nearly, or 36.5 pounds at each handle.

Compare this with the result obtained when we neglected friction; instead of 6.5 pounds at each handle, we have 36.5 pounds, 30 pounds of which is wasted in overcoming frictional resistances within the machine, and thus the efficiency is reduced from 100 per cent. to $\frac{1,250}{6,910} = 18$ per cent., nearly.

To increase this efficiency, we might change the design to that shown in Fig. 15, in which the screw is smaller in diameter and the end thrust bearing at *3* is greatly reduced. In this design, the frictional work done at the vertical guides *1* and *2* is so small that it may be left out of consideration.

The work done at *3* is
$400 \times \frac{3}{8} \times 3.1416 = 471$ inch-pounds. (*a*)
The work done at *4* is
$400 \times \frac{3}{4} \times 3.1416 = 942$ inch-pounds. (*b*)

Adding (*a*) and (*b*) together, we find the total amount of wasteful work done to be 1,413 inch-pounds. The useful output is the same as before, namely, 1,250 inch-pounds; and $1,250 + 1,413 = 2,663 =$ total work done, and also total input; the efficiency of the machine is, therefore,

$$\frac{1,250}{2,663} = 47 \text{ per cent., nearly.}$$

It should be the aim of the mechanical engineer to make the efficiency of every machine he designs as high as possible, with which end in view he should bear in mind what the above example proves, and what it has been the writer's endeavor to demonstrate: That in proportion as he lessens the distance through which any frictional resistance has to be overcome, he decreases the wasteful work done within the machine, and therefore increases its general efficiency.

TO SPLICE A WIRE ROPE.

(*By Permission of "Mines and Minerals."*)

W. H. Morris.

A Method by Which a Wire Rope Can be Spliced in From Twenty to Thirty Minutes. Tools Required, and Instructions in Detail.

THE writer does not claim anything necessarily new and original in the following method of splicing, but he has not seen it in use at any other place. It has resulted from his own practice, and, after trying many methods, this one has been adopted as the simplest, most rapid, and most satisfactory one for use with the tail-rope and endless-rope systems.

The only tools needed are a cold cutter and hammer for cutting and trimming the strands, and two "needles" 12 inches long. These latter are made of good steel, ½ inch thick at one end, tapered ovally to a point, and having a handle riveted on, as shown in Fig. 3.

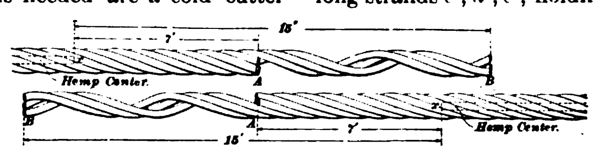


Fig. 1.

When the rope is cut and ready for splicing, unwind three strands of each part back 15 feet, keeping them together and not separating them. Now cut out the hemp center to the point *x*, as shown in Figs. 1, 2, and 3; rewind the strands for 7 feet to *A*, and cut off three of them from each end of the rope at *A*, *A*, Fig. 1. Then, as shown in Fig. 1, from *x* to *A* the rope is without a hemp center. Draw the two ends *A* together, letting *B*, *B* pass, as shown in Fig. 1; uncoil the strands *e*, *d*, *c*, Fig. 2, keeping them together, and follow immediately with the long strands *e′*, *d′*, *c′*, holding all the strands firmly and keeping them together so that the three long strands *e′*, *d′*, *c′* will take the place of the short strands *e*, *d*, *c*; next, do the same with the strands *f*, *a*, *b*, keeping them together as before, and laying them in the places from which *f′*, *a′*, *b′* have been uncoiled. Take about two turns around the rope with these; the operator will then find that the rope is united and round, as shown at Y,

Fig. 3. Now take the short strand a', Fig. 2; unwind it, and follow with the long

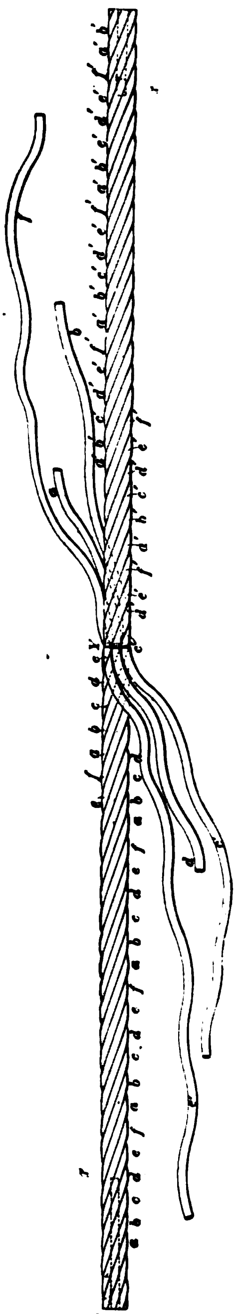


Fig. 2.

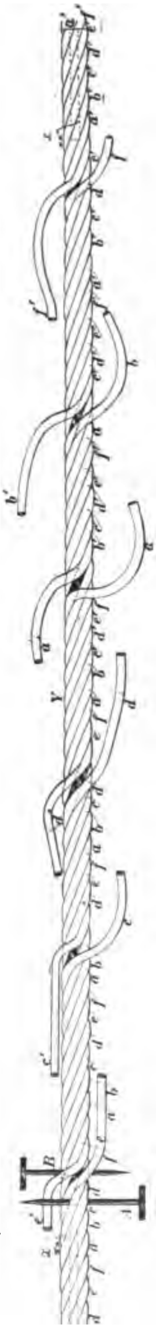


Fig. 3.

strand a, making two wraps or turns around the rope; then unwrap the short strand b', and follow it with the long strand b, making the long end fit in the place previously occupied by the short strand of the same letter; do the same with f, e, d, and c, until the last strand reaches x, Figs. 1 and 3, at the two ends of the splice. By following these directions closely it will be unnecessary to tie the strands, as each strand locks the other, and there is no danger of entanglement if care be taken that the strands follow one another in their natural order.

After cutting off the ends of each strand the rope will have the appearance shown in Fig. 3, where, if the ends were tucked in, e' would butt against x, e against c', c against d', d against a', etc. The next operation is to run the strands into the middle of the rope. To do this, push the needle A, Fig. 3, through the rope from the under side, having three strands in front of the needle and two at the back, the strand e being back of the needle. Push the needle B through from the upper side, having the strand e in front of the needle; push the needles as close together as possible with the strand e between them; place the needle A on the knee and hold it there firmly, then turn the needle B around the coil of the rope, forcing the strand e' into the center of the rope. Continue similarly with all of the strands, and should any of them seem too full tap them lightly with the butt end of the needle, which will round them off and fix them into place. All of the strands should meet as nearly as possible in the center, as they take the place of the hemp center and this will keep the rope round and prevent the slipping of the strands.

The splice as thus made may seem at first somewhat rough, but a little use of the rope will overcome all irregularities. I would advise a beginner to make several splices on rope that is not in use. I am sure that, if the above directions are followed, after a little practice any man can make such a splice in thirty minutes, and when pushed I have frequently had a splice made in twenty minutes; but this requires two men, one coiling and uncoiling, while the other follows up with needles and cold cutter. To do this the hemp center must be left out, as shown in Fig. 1.

A new rope, owing to the wild character of the strands, must have the hemp center left in; otherwise, the operation is the same, excepting that, when ready to run in the strands, the needle is pushed through at x, Fig. 3, and turned so that its broadside will

be at right angles to the rope; cut the hemp center and pick out enough of the center by turning the needle around the coil of the rope to let in the strands e' and e; put in e' and e, and then push the needle through at the end of the strand e, taking out enough of the hemp center to put in the strands c' and c; continue thus until all the strands have been entered. With a new rope it will take 1 hour to make the splice.

As to the strain that such a splice will sustain, we haul 50 cars per trip, giving a total of about 142 tons. This trip is started on a grade of 1½ per cent. against the load; the distance from the power house to the side track in the mines is 13,000 feet, and this splice will run from six months to a year, hauling daily from 12 to 15 trips.

THE ALPHABET, AND THE ART OF LETTERING.

Chas. J. Allen.

Early Forms of the Letters That Constitute the English Alphabet of Today—The Development of Different Styles From the Few Original Forms.

PART II.

We have learned thus far that writing began with ideographs, or picture words, and that there was a gradual transition from them to the phonetic alphabet used by the Greeks. The general changes we quickly followed, starting from hieroglyphic Egypt, thence to Palestine and Phœnicia, and finally to Greece. But what, may be asked, has the Greek alphabet to do with ours? This question brings us at once to the alphabet in modern history, a branch of the subject that should be of interest to all.

We will assume that the reader is familiar with the phonetic value of each of the twenty-six letters now in use, and will direct his attention immediately to some of the 800 different styles of letters that during the past 1,900 years have been developed from the few original forms.

Taking the alphabet as we find it in the beginning of the 1st century, and turning from the land of its birth to southern Europe, the land of its adoption and subsequent development, let us follow its growth through the marked periods of later history. To do this intelligently it will be well first to note that, 1,900 years ago, our present Great Britain, Germany, and all northern Europe were the home of uncivilized, half-savage people; this should be kept in mind while following the changes that led to the present alphabet. The golden milestone in the center of the city of Rome marked at that time not only the center of a city, but also the center of the vast Roman empire, then at the zenith of its ascendency—an empire that had inherited much, though not all, of the greatness of fallen Greece. It is to the city of Rome that we have to look for all evidences of the letters used at that time, and there we find the best monumental witness in the Arch of Titus. A study of the letters on the entablature of this arch, which was erected in the year 70, reveals a quite surprising similarity to those now in use. The letters are Latin, and belong to an alphabet derived from the Greek, Etruscan, and Ionic; their general form is similar to that used by the Greeks, but there is added a spur, or triangular point, at the extremity of each stroke. The Latin alphabet is the parent of all our present types of lettering, and therefore claims special attention and study. Owing to political causes it finally displaced all other national scripts of Italy, and as the alphabet of Rome it became that of Latin Christendom and, finally, the literary alphabet of Europe and America, and is thus the only one that can claim to be cosmopolitan.

The earliest manuscript specimen of the Latin language extant is a fragment of the hymn of the Fratres Arvales, a religious brotherhood that continued the Thanksgiving for the fertility of the land.

If the reader will compare the letters mentioned throughout this article with those illustrated in Fig. 3, he will be greatly assisted in becoming familiar with the styles known as fundamental, and the article will become of much more general interest to him. The three styles of lettering used during the 1st century were: *First*, that shown on the Arch of Titus, which corresponds to the antique

Egyptian of the present day; *second*, that of the uniform stroke without the spur, known as the Egyptian; and, *third*, that used by the Western Roman provinces (now Spain and France), which was made by reducing the horizontal strokes to about one-half the width of the vertical and adding the spur; this gave rise to a distinct style, known today as the French Roman.

Leaving the 1st century, so luminous with achievements in alphabet development, the Rome-divided period is entered, when the warlike and unsettled condition of all Europe and western Asia crowded out all possibility of advancement in art or literature, or, indeed, anything else, save only what could be gained by expeditions of war, until the 15th century was reached. Almost all the lettering that was given to the world during this long period was executed by the monks within the monasteries scattered throughout southern Europe. These ecclesiastical devotees, known also as *calligraphers*, exhibited wonderful skill in the art of engrossing, especially in designing and illuminating capitals on their manuscripts; many of these were copied from early Biblical records which, after being used to copy from, were removed by a chemical process from the parchment on which they were made, and thus the world was deprived of writings that were necessarily far more valuable than those of the monks.

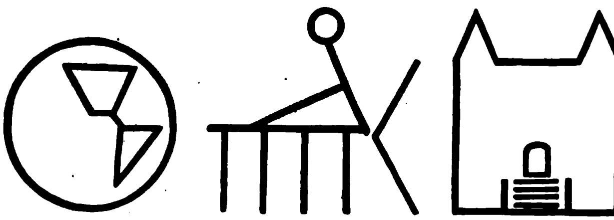
During this period the forms of the letters became more and more complicated, with a strong tendency to the grotesque, all kinds of figures and designs being made a part of a letter. But several plainer styles that are worthy of notice were also originated during the same period, one of which is the Romanesque of the 8th century, which gave rise to the Old English and German of the present day. The ornamental sarcophagus belongs to this age, and upon them there occasionally appears a line of lettering that serves to establish the exact period to which the relic belongs. But the dark ages were in reality a germinating or budding season, and culminated in an event which proved of the utmost importance to Europe, and in fact to all the world. About the middle of the 15th century, during the period known as the Renaissance (famous for a revival of art in central and northern Italy), a system for reproducing letters and drawings was invented which was destined to bring the most distant parts of the world into close touch, and be a means of imparting knowledge to all. This was the science of printing by means of movable type, invented by Johann Gutenberg, of Mentz, Germany, who perfected his invention and made it of practical use in the year 1443. It must be remembered that even at this date there was no cheap material upon which to print, parchment only being in use, so that

Fig. 1.—The Arch of Titus.

the great advantages that this invention was to bestow upon the nations were delayed somewhat.

To return to the alphabet: the forms of the letters had, during this long period, grown into complicated enigmas, so that the invention of printing was peculiarly opportune and beneficial, because in order that the letters might be used as movable type, the designs had to be greatly simplified. The early forms of Roman were therefore followed, as also was the Gothic; the latter was the classic letter of the medieval period, and derived its name from the pointed arch

PICTURE WORDS.
AS THE ANCIENTS WOULD HAVE WRITTEN IT.



HIEROGLYPHICS.
AS THE EGYPTIANS WOULD HAVE WRITTEN IT.

INTERNATIONAL CORRESPONDENCE SCHOOLS.
IN PLAIN ENGLISH.
AS WE WRITE IT.

FIG. 2.

then in vogue; the Gothic of the present day is almost identical with the original, the earliest specimen of which dates back to the year 1250. The medieval Roman letter is the extreme of the French Roman, in which the horizontal stroke is reduced in thickness until it becomes a fine line, from which type we may trace the origin of our present Roman letter.

Script writing, that is, the ordinary cursive kind, was the outgrowth of a great variety of text hands, and was brought into classical styles later by the Anglo-Saxons. Out of these has been finally developed the American Spencerian script, the most graceful form of freehand letter yet invented.

The monogram appears in various forms during the entire period of modern history, its present state being marked by symmetrical design and great artistic beauty, and it is now used in many practical ways.

The Italic script is a modern adaptation of the medieval Italic print. There are several forms of church text, each arising from a period that marks a corresponding architectural era; these are seen at the present time in many abbeys and cathedrals throughout Europe. The cathedral of Notre Dame, in Paris, shows what are without doubt the oldest specimens in existence of the French Gothic, bearing the dates 1163–1214. In Westminster Abbey, London, the Henry VII Chapel contains an original conception of the Gothic; this chapel was built in 1509, and shows a peculiar letter identified with no other place, which is one of the most classical of the early forms. The *old* forms of Old English still remain in many ancient abbey inscriptions. The tomb of Richard II, also in Westminster Abbey, bears a good specimen of this letter, of the year 1400. Many of the so-called Old English letters used today bear little resemblance to the original style, and should be known rather as *modern* Old English, if we may use such an expression. The minuscules, or small letters, known among printers and letterers as *lower case*, were first used during the medieval period.

Out of all these early forms to which we have referred, there has grown an almost endless variety of styles; for these we are indebted to competition among printers and type manufacturers, who, in their efforts to create a demand for their own work, have displayed much originality of design. The Bradley text serves as an excellent example of one of the most popular of these.

The styles of letters so familiar to all that notice the artistic productions of the sign

painter and printer have in many cases been originated in this country, and many of them have become so popular the world over as to bear the distinct name of American writing. Among these are included full block, square, and round, half block (both plain and antique), railroad block, shippers' box-marking, and Spencerian script. The engrossing text, or German rund-Schript, and the pens used for writing it, were the invention of a German.

From the principal styles shown in Fig. 3 there has arisen an immense number that can be seen in any printers' type book. All letters can be classed as either plain, ornamental, or grotesque, and an unlimited variety of designs is possible. Again, by various forms of shading it is possible to so change the general character of a given style as to completely hide its identity, and yet such shading does not constitute a new style, and does not necessarily call for much originality.

Thus, then, has the art of lettering come to be what it is today—from picture words to hieroglyphics, and from hieroglyphics to a perfect phonetic alphabet composed of twenty-six letters. In Fig. 2 we have tried to give the reader a definite idea of how badly off we would be if we had to resort to picture words, and to show how these same picture words might gradually become mere conventional signs, or hieroglyphics; we have also given the same words in plain English.

We have said that the art of lettering owes much to the invention of printing; but it is also true that the greatest visible improvements in the work done by the modern printing press is due to improvements that have been made in the designs of the letters used, and it must not be forgotten that the excellence and finish of these designs depends primarily upon the skill and knowledge of the letterer. The improvements that have been made during the past fifty years are best realized by comparing the high-grade magazines of today with the best of half a century ago. It is not, however, to the type designer alone that a knowledge of the art of lettering is valuable; no man should be ignorant of it, whatever his occupation, but in particular, mechanical draftsmen and all designers, no matter in what industry, should have an intimate knowledge of how to construct every letter in the alphabet in the several designs in every-day use.

FIG. 3.

THE PLANETARIUM.

George McC. Robson, M. A.

Astrology—The Wanderers, and Their Influence on Languages and Institutions. Pythagorean Speculation Revived by Copernicus—Harmony of the Spheres.

THE ancients regarded the heavens as an immense spherical dome, to the inner surface of which the heavenly bodies were attached. They naturally conceived that the earth was the center of this great vault, and that the celestial orbs performed a ceaseless journey around the earth. The earliest observers could not fail to be struck with the fact that most of the heavenly bodies preserved, night after night and year after year, the same relative positions. On the other hand, a few of the most conspicuous of the celestial objects were seen to be continually moving to and fro among the others. These bodies, which seemed to move according to no regular law, were called *wanderers*. Of these the ancients recognized seven, viz., Sun, Moon, Jupiter, Venus, Mars, Mercury, and Saturn.

For many centuries it was firmly believed that the heavenly bodies exercised a controlling influence upon human affairs; their positions and motions, therefore, were attentively observed, in order that men might gain therefrom some indication of the probable course of future events. Thence arose the pseudoscience of astrology, which long usurped the place of astronomy, and has left an indelible mark in the language and institutions of every people under heaven. For example, the English word *consider* is derived from the Latin word *sidus*, "a star," and literally means "to consult the stars"; *disaster* is from the Greek word *astron*, "a star," from which we also derive the words astrology and astronomy, and disaster means that our star is unfavorable; the derivation and meaning of ill-starred are self-evident.

The week of seven days belongs exclusively to those tribes and nations who recognized seven wanderers. The Incas of Peru recognized only the sun, moon, and Venus; and their week had nine days, this period being adopted, probably, because it is one-third of the period of the moon's revolution about the earth. The Aztecs of Mexico also knew only the sun, moon, and Venus, and their week had thirteen days.

The ancients dedicated the hours successively to the wanderers in the order of their distances from the earth. Saturn, on account of his dimness and the slowness of his motion, was considered to be the most remote. From such considerations the wanderers were ranked in the order of their distances from the earth as follows: Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon. The first hour of the first day was given to Saturn, the second to Jupiter, the third to Mars, the twenty-second to Saturn, the twenty-third to Jupiter, the twenty-fourth to Mars. Hence, the first hour of the second day belongs to the sun, the second hour of

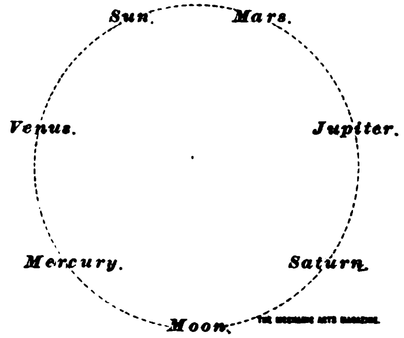


Fig. 1.

the second day to Venus, and so on. Each day was named after the wanderer to which its first hour was consecrated; the wanderer for which each day is named can be determined by following out the process indicated above, but the following method is easier: Write the names of the wanderers in order around a circle; begin with Saturn and skip two every time; then, they fall into the following order: Saturn, Sun, Moon, Mars, Mercury, Jupiter, Venus. Now, Saturday is simply Saturn's day, Sunday is Sun's day, and Monday is Moon's day. The French name of Tuesday is Mardi, or Mar's day; the English name Tuesday preserves the name of the god Tyr, who in Norse mythology was god of war and corresponded to Mars of the Roman mythology. Wednesday in French is Mercredi, or Mercury's day; the English word is derived from the name of the god Woden, who among our ancestors filled Mercury's place. Thursday takes its name from Thor, the god of

thunder, who was the Norseman's Jupiter. In Latin, Friday is Venus's day; the Scandinavians, Anglo-Saxons, and Germans named Friday after their goddess of love, Frigga, who corresponded to Venus. In ancient times, Friday, being dedicated to the goddess of love, was the lucky day. To the veneration of the ancients for the celestial bodies is also to be ascribed the mystic significance attributed by them to the number seven.

Nothing is known of the date of discovery or of the discoverer of any of the wanderers. After the sun and moon, Venus was undoubtedly the earliest known; it is so conspicuous as the morning or evening star that it must necessarily have been distinguished from the rest of the heavenly bodies by the earliest observers. It is extremely probable that Mercury was the latest to be added to the list, for, owing to its proximity to the sun, it can be seen only under very favorable circumstances; yet even Mercury was recognized in prehistoric times, and we find references to it in writings dating back more than twenty centuries.

The system of astronomy that regarded the earth as the fixed center of the universe is called the *Ptolemaic* system, after Ptolemy, a famous mathematician of Alexandria, who died in 168 A. D. Ptolemy knew that the earth was a globe, and that its diameter was so small, in comparison with the distances of the heavenly orbs, that he was justified in treating the earth as a mere point. He also knew that the celestial motions could be explained by supposing the earth to move, and he gave reasons for rejecting this supposition. The early geometers regarded the circle as the only perfect figure, and consequently they believed that all the celestial motions must be circular. But they observed the wanderers moving now forwards, now backwards, among the fixed lights of heaven; and these apparent motions had to be reconciled with the assumed circular motion. Ptolemy supposed that each body moved in a circular path, while the center of this circular path itself described a circle around the earth. He displayed great ingenuity in perfecting this theory; and his beautiful system of epicycles, though somewhat complicated, affords a satisfactory explanation of all the phenomena with which he was acquainted. He gives a description of an instrument called the *astrolabe*, by means of which the celestial motions can be exhibited in accordance with his theory.

Modern astronomy is all based on what is known as the *Copernican* system, because it owes its origin to the brilliant conjectures of Nicholas Copernicus, who died at Frauenberg on May 7, 1543. He first clearly pointed out the distinction between real and apparent motions, and maintained that the apparent daily motion of the heavens is really due to the rotation of the earth on its axis; he formed this theory because it is simpler to think of the earth rotating with a comparatively moderate velocity than to imagine the stars sweeping through space at the utterly inconceivable rate required by the Ptolemaic theory. He further assigned to the earth its proper place in the universe by making it revolve about the sun. Besides the earth there are several other bodies revolving about the sun; these and the earth also are called *planets*. Some of the planets have smaller bodies revolving about them as they revolve about the sun; these smaller bodies are called *satellites*. All these bodies, great and small, with the sun as their center, constitute the solar system. Thus, of the wanderers of the ancients, one—the sun—has ceased to wander, another—the moon—has been reduced to the rank of a satellite, and the rest have been elevated into planets.

The theory of Copernicus is justly described as a conjecture or speculation; for he had no proof of it, and merely framed it as a simple explanation of the facts as he knew them. By the labors of later scientists it has been abundantly shown that this theory explains every observed phenomenon, and enables us to predict with unerring certainty future phenomena, and to fix the exact time and place at which they will occur. Thus, what to Copernicus were merely probabilities, have now became established facts, and the hypothesis has been recognized as a law of the universe. This is the way in which great scientific discoveries are invariably made. A speculator of sound and vivid imagination, who knows some facts, invents a more or less plausible theory to explain and harmonize those facts; this speculative theory is then worked out to its legitimate conclusions, and the consequences to which it leads are determined. Then every ascertainable fact is carefully examined; if they are all found to be consistent with the theory, and if it accounts for them all, the speculative theory becomes a natural law. When a speculative theory is thus tested by comparison with facts, it is generally necessary to modify the theory somewhat, and not infrequently a very plausible theory proves utterly untenable and has to be abandoned. But many a theory long since abandoned, and

only remembered to be sneered at by the thoughtless, has been very useful in its day and generation.

An attempt has been made to prove that the true scientific method is to observe and collect facts, and gather a great mass of systematic observations; then, having examined and classified these recorded observations, to arrive by a process of induction at the law that governs them. But this method has ever been barren of results. The mere collection and classification of observations, unguided by some sort of theory—good or bad—has always resembled the mountain in labor which brought forth a mouse—the results have been scant and small. Science is something more than a mere epitome and distilled essence of statistics; scientific investigations cannot be conducted and great discoveries made by an automatic recording machine; a pencil and an algebraic formula do not constitute a pioneer of science any more than a fur coat makes an arctic explorer. The scientist needs a good imagination, and he must give it full and unfettered play. The sublimest flights of the human imagination are not to be found in the works of poets and novelists; beside the brilliant fancies of such men as Kepler and Newton all the tales of mystery and imagination of fiction are pale and insipid. In the mere matter of observation, Copernicus was at a disadvantage compared with many of the ancients, for at the end of his life he deeply regretted never having seen Mercury. His immortal discovery was the fruit of his free and fertile imagination.

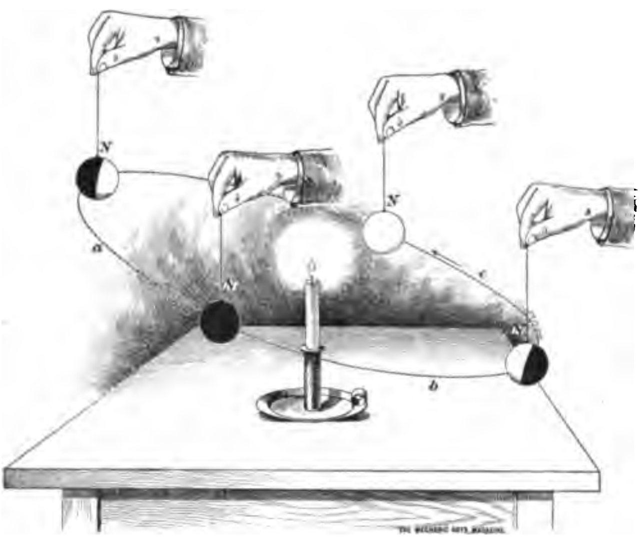


FIG. 2.

It is right to mention that the speculation of Copernicus had been advanced by Pythagoras, who died in 500 B. C., but had been lost sight of under the reign of the peripatetic philosophers. Pythagoras believed that the distances of the heavenly bodies from the earth formed a musical progression, and this theory of his has given us the phrase, "harmony of the spheres."

In picturing to ourselves the motions of the heavenly bodies, we encounter three great difficulties. In the first place we have no stationary place from which to watch them. Secondly, the universe is so vast that we can form no adequate conception of its proportions. In the third place, the mighty orbs of heaven move with such majestic dignity, and occupy such long periods in making a circuit of their courses, that the brief span of human life is utterly insufficient to trace their paths. We have mentioned that the ancients met the two latter difficulties by the invention of the astrolabe, which represented the motions on a scale of magnitude and in a period of time convenient for observation; the first of these difficulties was, however, insurmountable until the Copernican system was established. This difficulty may be illustrated by reference to a beautiful mosaic floor in a great cathedral. To see the beauty of this floor one must view it from the proper position. From any other point of view the spectator sees nothing in the pattern but an intricate confusion of meaningless lines and a mass of discordant colors. As soon, however, as the guide places him in the proper position, the picture bursts upon his enraptured vision in all its beauty of outline and harmony of color. In like manner, to feel and realize the harmony of the spheres, and get a true view of their motions, one must be transported in imagination to the sun; then all the confusion disappears, and the motion of every body is simple and direct.

Some of the mathematicians of the seventeenth century invented machines, known

as *planetariums*, to exhibit the motions of the solar system in accordance with the Copernican theory. The first of these machines was invented by Huygens, and is still preserved at the University of Leyden. In designing the gear-wheels of this machine, Huygens used the method of continued fractions, and this was the first practical application of that method. (See HOME STUDY MAGAZINE, August, 1898, article entitled "Continued Fractions.") The planetarium shown in Fig. 3 was constructed by William Jones, a mathematical-instrument maker of London. It is driven by means of a handle that is connected with a system of gear-wheels so accurately calculated that the motions are correct within one minute of time. The wanderers of the ancients are all represented; namely, the sun ⊙ in the center, Mercury ☿, Venus ♀, the earth ⊕ with the moon ☾, Mars ♂, Jupiter ♃, with his moons, and Saturn ♄ with his ring and moons. Each of the wanderers is denoted by a symbol, Saturn's symbol being the conventional representation of an old man leaning on a staff, in which guise the god Saturn was always presented. The symbol for Mars is a man with a spear protruded. Since the invention of the telescope, other planets have been discovered, and additional arms are sometimes placed on the planetarium to show their motions.

Confining our attention to the older planets, we shall point out some of their motions and other characteristics.

1. Each of these planets moves around the sun in a nearly circular path, called the *planet's orbit.*

2. They all revolve around the sun in the same direction, and their orbits are nearly in the same plane.

3. Each rotates on an axis passing through its own center; the plane of rotation coincides nearly with the plane of its orbit, and the direction of its rotation is the same as the direction of its revolution around the sun.

4. The satellites of a planet revolve around the planet in a plane nearly coincident with the planet's orbit, and the direction of the satellite's revolution is the same as that of the planet's rotation.

5. The largest planets rotate most swiftly.

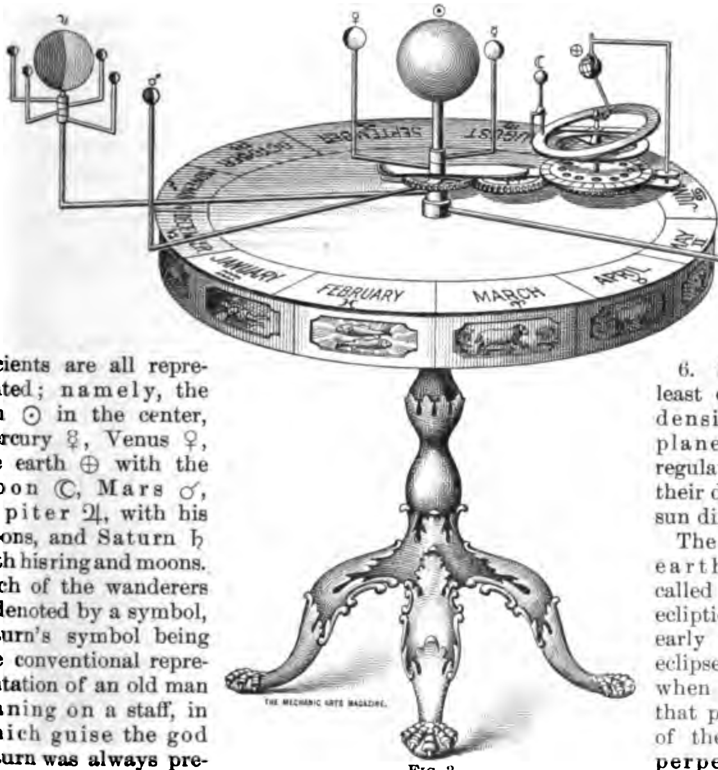


FIG. 3.

6. Saturn has the least density, and the density of these old planets increases in a regular progression as their distances from the sun diminish.

The plane of the earth's orbit is also called the plane of the ecliptic, because it was early observed that eclipses happened only when the moon is in that plane. The plane of the equator, being perpendicular to the earth's axis, may be taken as the plane of the earth's rotation; we have already said that this plane is nearly coincident with the plane of the ecliptic; the angle between these two planes is called the *obliquity* of the ecliptic; it is very nearly constant, and its present value is about $23\frac{1}{2}°$. Since the obliquity of the ecliptic is practically constant, it follows that the axis of the

earth is inclined to the ecliptic at a constant angle; in other words, the axis of the earth moves parallel to itself. Jones' planetarium has a frame attached to the earth and the moon; this frame contains four wheels and two pinions, and preserves the necessary parallelism of the earth's axis. The earth in this machine is usually represented by a 3-inch globe. By placing a lighted candle for the sun in the center, the changes of the seasons and the different lengths of nights and days will be represented more conspicuously. The succession of the seasons can also be represented by the simple construction shown in Fig. 2. The candle represents the sun; *a b c* is the earth's orbit, and is erected so that its plane is inclined to the horizontal at an angle of 23½°. The earth is represented by a small ball, suspended by a thread attached to the hook *N*, which represents the north pole. The ball is carried round the orbit in the direction indicated by the arrow.

All the rotations and revolutions here referred to take place in the direction opposite to that in which the hands of a clock rotate. Hence, a counter-clockwise rotation is considered positive, and a clockwise rotation is regarded as negative.

The obliquity of the ecliptic is very nearly constant, but is decreasing at the rate of about half a second a year. This fact was observed in very early times; and gave rise to the ancient Egyptian tradition, recorded by Herodotus, that the plane of the ecliptic and the plane of the equator were originally perpendicular to each other. The Chaldean astronomers calculated that the obliquity of the ecliptic was diminishing almost at the rate of one minute in a century. These facts put us in a position to read history backward, and to discover why the Chaldeans asserted that their nation had been in existence and had preserved astronomical records for 403,000 years before Alexander entered Babylon. A very simple arithmetical calculation shows that at the rate of a very little less than one minute in a century, it would require 403,000 years to reduce the obliquity from 90° to something more than 23½°. The Chaldean assertion, then, that their empire had lasted 403,000 years, was their way of saying that it began with the beginning of the world.

Next to the sun, the moon is the most interesting of our celestial neighbors; indeed, the Hibernian astronomer, waxing poetical in his cups, assigns to the moon the place of honor, when he says:

Long life to the moon, for a dear noble cratur,
  Which serves us for lamplight all night in the dark,
While the sun only shines in the day, which by natur
  Wants no light at all, as ye all may remark.

It is remarkable that the moon rotates on her own axis, and yet continually presents the same side to the earth. This feat she accomplishes, with true lunar ingenuity, by making the period of her rotation coincide with the period of her revolution round the earth. Any one can perform the same feat by placing a chair in the middle of the floor and making a circuit of the room, at the same time continually facing the chair. If he starts with his back to a window, by the time he has made half the circuit of the room he will be facing the same window, and consequently must have made half a rotation on his own axis; on completing the circuit he will have made another half rotation.

The triumph of modern astronomy has been so complete that even the satire of its opponents is no longer satire, but sounds like sincerest praise. An astronomer may now assume as a motto the verses in which the author of Hudibras satirized what he regarded as the presumptuous pretentions of astronomers:

To carry this most virtuous war
Home to the door of every star,
And plant the artillery of our tubes
Against their proudest magnitudes;
To stretch our victories beyond
Th' extent of planetary ground,
And fix our engines, and our ensigns
Upon the fix'd stars vast dimensions,
(Which Archimede, so long ago,
Durst not presume to wish to do),
And prove if they are other suns,
As some have held opinions,
Or windows in the empyreum,
From whence those bright effluvias come
Like flames of fire (as others guess)
That shine i' th' mouths of furnaces.

TORPEDOES.

Ernest K. Roden.

CONSTRUCTION AND OPERATING OF THE MOST FAMOUS TYPES—THE WHITEHEAD AND ITS AMERICAN RIVAL, THE HOWELL—THEIR DESTRUCTIVE POWER—PROTECTION OF SHIPS.

THOUGH the science of naval warfare is many centuries old, the torpedo—the most destructive death-dealing engine of war ever employed by man against man—was invented only thirty-eight years ago. Thus it is the most modern as well as the most formidable weapon used to destroy life and property on the high seas—most formidable, that is, when properly aimed; for in its effects upon the enemy the torpedo somewhat resembles the verdict of a jury in a murder case, which, if it does not condemn to death, lets off scot free. There is nothing half-hearted about a torpedo.

Not many years ago the torpedo was generally looked upon as something unclean and devilish, as an illegitimate engine of warfare, unfit to be employed by an honorable adversary. But this view has been dispelled, and at the present day the torpedo occupies a front place among the fighting tools of all the great navies of the world.

Torpedoes may be divided into two general classes:

1. The dirigible (directable or steerable) automobile torpedo, which is aimed, launched, steered, and exploded electrically through a wire connecting it with a vessel or a shore station.

2. The self-steering torpedo, which, after being started on its course, makes its own way beneath the surface of the water and is exploded by striking the object of its attack.

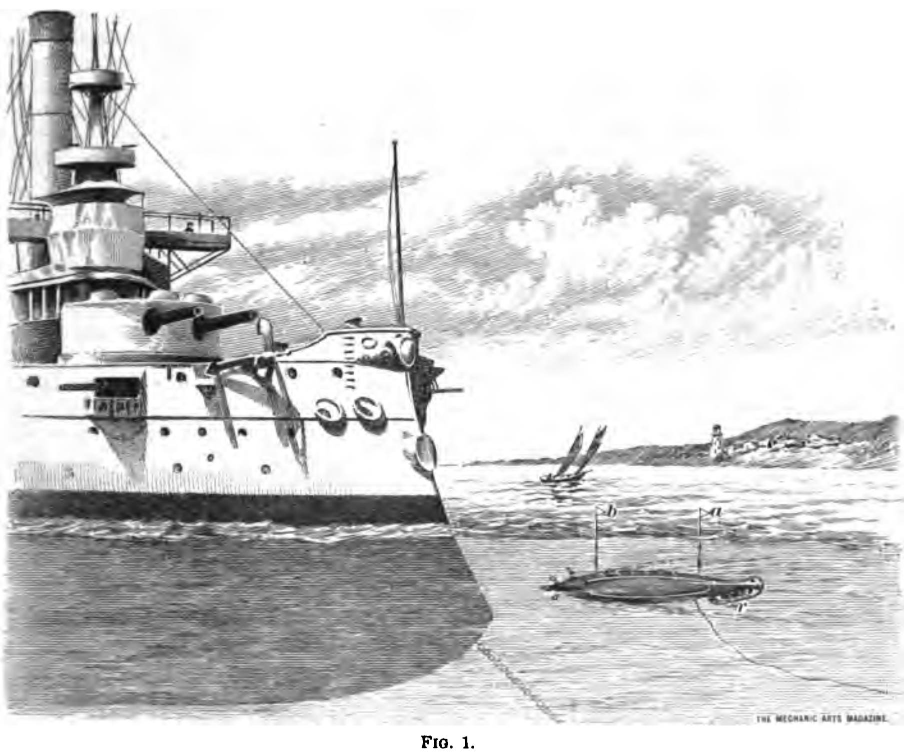


FIG. 1.

The dirigible torpedo, steered and controlled by electricity, was first patented in England in 1870, and in 1872 was patented in this country by Lieut.-Col. Foster, United States Engineers; since then it has been independently elaborated by Lay and Smith. It consists essentially, as shown in Fig. 1, of a cigar-shaped vessel of boiler plate, which

carries and, as it proceeds on its journey, unreels a coil of insulated wire, through which the electric current from a battery either on shore or on shipboard can be passed at will to certain electromagnets. By closing and breaking the circuit, and reversing the direction of the current, valves connected with the motive power are controlled and

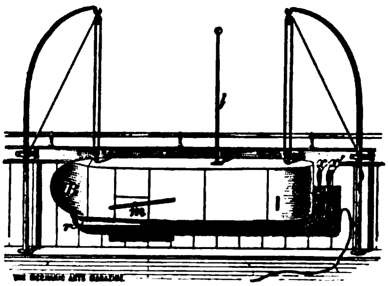


FIG. 2.

the rudder *r*, Fig. 1, is put to port or starboard and the engine is started or stopped at the will of the operator. In this manner the torpedo is under perfect control from the instant of starting. The motive power may consist of liquid air, of ammonia, of compressed air, or of steam peculiarly applied. The torpedo may be made to swim either at the surface or below it. In the daytime its position is made known to the operator by two small flags *a* and *b*, Fig. 1, carried near the water level; at night these flags are replaced by lanterns shaded in front, so as to be invisible to the enemy. Any of the modern explosives may be used and detonation caused by the action either of a mechanical fuse or of a circuit closer and battery.

Another dirigible automobile torpedo, which at one time attracted a great deal of attention, was invented by Capt. John Ericsson. This consists, as shown in Fig. 2, of a box of thin steel plates, 8 feet 6 inches long, 30 inches deep, and 20 inches wide, at the bow of which, at *B*, the explosive charge is placed. It has two propellers *x* and *x′*, 3 feet 2 inches in diameter and of 5 feet pitch, which revolve around a common center but in opposite directions. The motive power is a small double-cylinder oscillating engine driven by compressed air from a 25-horsepower steam engine on shore, which is transmitted to the torpedo through a tubular cable connected just abaft the stern. The air pressure also governs an equipoise rudder *r* secured under the bottom near the bow. Steering is effected by the force of the compressed air acting against one side of the tiller, and a spring acting against the other side. The submerging is regulated by two horizontal rudders *m*, one on each side, turning on a transverse axle near the bow. These rudders, or wings, are so constructed that by them the torpedo can be kept at a depth of from 7 to 12 feet, and they are provided with automatic devices that make it impossible for the latter limit to be exceeded. In order that the course of the craft may be followed there is secured to the deck a light steel mast *l* 12 feet long which terminates in a wooden ball; the forward side of this ball is painted sea green so as to be practically invisible to the enemy, and the rear side white so as to be easily seen by the operator. Opening into the engine compartment are holes through which the water is permitted to freely enter and completely fill the interior space; thus the machinery is enveloped in water, and so, being made of bronze, with boxwood bearings, needs no other lubricant, and stuffingboxes at the rudders are done away with. The torpedo is launched from the davits, as shown.

The second, and more successful, class of offensive torpedo is best represented by the Whitehead type. This weapon, which has been generally adopted by the governments of Europe and partially by the United States, represents the development of an idea originally put into shape in 1860 by a Captain Lupuis of the Austrian Navy. The first

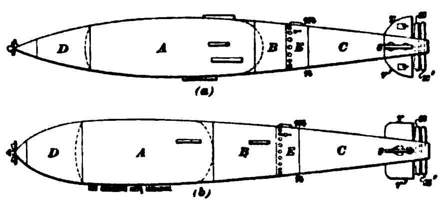


FIG. 3.

design consisted of a torpedo boat to be driven by a hot-air engine and to contain a heavy charge of guncotton. It was intended that this should swim at the surface of the water and be guided and exploded from the shore. In its conception it was, therefore, somewhat similar to the dirigible torpedo already described. Mr. Robert Whitehead, at that time manager for an engine-building company in Fuimes, Austria, was consulted by the inventor, and by his skill and mechanical ingenuity an entirely novel form of torpedo was produced, which today, in its now almost perfect shape, embodies the

thought and study of nearly a quarter of a century.

There are several types of the Whitehead torpedo, two of which are shown in Fig. 3. The dimensions vary from 14 feet to 19 feet in length, and from 14 inches to 19 inches in diameter at the largest part. At (a) is represented an early pattern, and at (b) one of the very latest. It will be noticed that in the former the head, or foremost part, is shaped fine, while in the later type it is blunt. On first consideration it might be supposed that the finer the head the less the resistance offered by the water; but this is not so, as a glance at the head of any fish remarkable for speed and power of turning at once suggests, all such fish being blunt-headed and tapering away at the tail. The lesson thus taught by nature was well borne in mind when the latest design of the "Whitehead" was made.

The torpedo itself is divided into compartments, or sections, of which the foremost D contains the explosive charge and the firing rod. When the head of the torpedo comes into contact with a ship or any rigid object, the rod is driven in against a detonator and the charge exploded. Behind section D is an *air chamber A*, which contains the power—namely, compressed air—that drives the torpedo, just as the boiler of a steamer contains the steam power that drives the ship. The size of this air chamber in relation to the whole torpedo is shown in the figure; it is made of a solid piece of the finest quality Whitworth compressed steel, just a trifle under $\frac{1}{16}$ inch thick, and the ends are made convex so as to better withstand the enormous pressure to which they are subjected. In order that the interior of this chamber may be examined it is fitted with *sighting plugs.* The air is forced in by the air-compressing pumps invariably found in vessels that carry torpedoes. Next to the air chamber is the *balance chamber B*, in which is stored the wonderfully ingenious apparatus that maintains the torpedo at its proper depth in the water; it is this apparatus, the outcome of Whitehead's high mechanical ingenuity, that has made this torpedo famous; the same chamber also contains the several valves by which the delicate mechanism of the whole is adjusted. A complete description of the contents of this chamber would fill several pages of this magazine, and we must therefore leave them unexplained. The next compartment is the engine room E, containing the *servo-motor*, the *engines*, and the *charging valve.* The engines are single-acting three-cylindered; the crank-chamber and the casings for the slide valve form one casting; the valves themselves are cylindrical, and, unlike the ordinary slide valve of a steam engine, perform only the operations

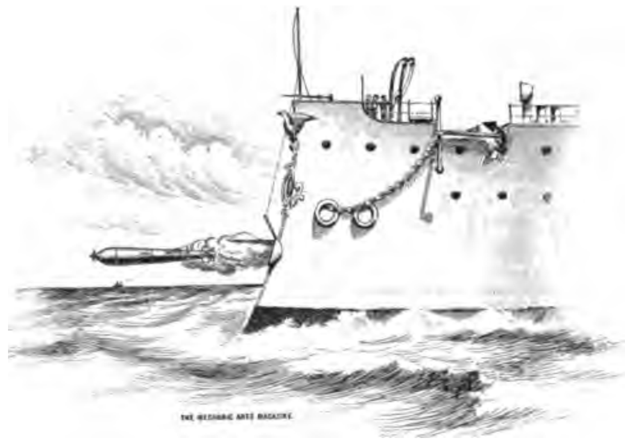


FIG. 4.

of admission and cut-off, the exhaust taking place through ports in the end of the cylinder. The great advantage possessed by these engines is that there is no possibility of their ever being "hung up" by getting on a dead center; they are driven by compressed air from the air chamber, and they rotate a shaft on the axis of the torpedo, on the end of which are fixed two screw propellers x and x' that revolve in opposite directions. These propellers drive the torpedo through the water at an exceptionally high speed. Further aft is a compartment C called the *buoyancy chamber*, the purpose of which is, as its name suggests, to give to the torpedo its necessary buoyancy. As this chamber is necessarily subjected to considerable pressure from the outside, it is supported on the inside with several flat steel rings, and to insure that the torpedo shall always swim in a perfectly upright position there is here stored a certain amount of ballast. The engines themselves are entirely shut off from this compartment by the bulkhead $m\,n$ to which they are secured; in the center of this bulkhead the tube for the propeller shaft is permanently fixed. The shaft passes right through

the buoyancy chamber, and the bearings for it are made thoroughly water-tight by means of asbestos packing. The diving rod connecting the balance-chamber mechanism with the rudders r and r' also passes through this compartment.

The torpedo is fitted with four rudders, two vertical (r and r'), and two horizontal (s and s'); the purpose of the latter, which are much larger than the vertical rudders, is to keep the torpedo at its proper depth below the surface of the water, and hence they are operated by the mechanism contained in the balance chamber. The pitch of both propellers is the same, namely, three feet; their diameters vary slightly.

A torpedo is "fired" from a tube, commonly called the *torpedo tube;* it is blown out either by compressed air or by the explosion of a small charge of gunpowder, the air pressure varying from 300 to 600 pounds per square inch, and the charge of powder from 4 to 4½ ounces. The mode of firing a torpedo by means of submerged tubes, that is, from tubes built into the ship's bow, stern, or side, below the water-line, is quite difficult and complicated, but possesses the great advantage of reducing to a minimum the risk of the torpedo's being hit, before it leaves the ship, by the enemy's shot or shell. In a close naval engagement, the use of above-water tubes is exceedingly dangerous, for should the head of the torpedo be struck, the chances are that the destruction intended for the enemy would be visited upon the firing vessel.

The apparatus for aiming the torpedo and for releasing it is quite as ingenious as the torpedo itself, but is kept a profound secret, the naval authorities of each nation taking the greatest care not to allow any foreigner to learn anything about the details of its construction.

All Whitehead torpedoes when fired from above-water tubes, as in Fig. 4, jump clear of the ship's side for about fifteen feet, then plunge headforemost into the water like a great fish, dive to a depth of about twenty feet, then immediately shoot up again (by reason of the action of the water valves regulated to open and close under certain pressures), then, for a hundred yards or so, pursue a slightly undulating course, and finally proceed steadily in a plane parallel to the surface of the water. The torpedo can be set so that in the event of its not striking the ship aimed at, it will stop and sink at the end of its range; or, for experimental purposes, it can be set so as to stop at any point within its range, rise to the surface, and float.

Regarding the speed and range, it may be mentioned that the pattern adopted by Austria is claimed to have a speed of 32 knots an hour, with a range of 437 yards, or of 30 knots with a range of 875 yards.

The secret of this torpedo was purchased by each of the governments of Europe, with one exception, for some $75,000. The exception was Turkey, who declined to buy because during the Russo-Turkish war of 1878 two of the missiles fell into the possession of the Turkish admiral, Hobart Pasha, at Batoum. The secret was thus at the mercy of the Turks, and the manufacturers hastened to crave the return of the two torpedoes, a favor which was granted in return for permission to manufacture the weapon without paying royalty.

The average cost of a Whitehead torpedo is about $1,500.

An Amerian rival of the Whitehead is the Howell, adopted by the United States Government. It was invented by Captain J. A. Howell, of the United States Navy, and is said to embody, with all the advantages of the Whitehead, superior directive powers. By some naval authorities, however, it is pronounced inferior in actual running and general handiness. Besides those mentioned, there are many other automobile torpedoes, such as the Peck, the Brennan, the Sims-Edison, the Maxim, the Lay, and the Nordenfelt, but space does not permit more than their mere mention here. The Lay (automobile) is especially interesting because it was employed by the Peruvians in their war with Chile in 1880, in which, however, it was not a success, owing to the ignorance of its users. The peculiarity of the Nordenfelt is that its motive power is self-contained electricity.

The simplest of all torpedoes is the "spar," which consists of a torpedo fastened to a long spar rigged out from the bow of a steam launch or other suitable vessel. To use it the launch is driven, bow on, against the side of the hostile ship, contact causing the torpedo to explode. The difficulty connected with this type is that it is necessary for the operator to go wherever the torpedo goes, and this is a pretty dangerous business; in fact, nowadays it is practically impossible for a spar torpedo boat to steam close to a wakeful vessel, coolly point the nose of her torpedo at her water-line and blow her up; should such a thing be attempted, the torpedo boat would, unless the whole of the enemy's

crew was asleep, be met with an overpowering storm of lead and steel from quick-firing and machine guns and would stand little or no chance of approaching within striking distance.

Before concluding, it may be fitting to say a word about the means employed to protect ships from the attack of torpedoes, in which connection it has to be admitted that nothing really effective has yet been invented or is ever likely to be. The only means hitherto employed consists of a strong network of wire rope or chain, suspended from booms so as to completely encompass the vessel. It is difficult, however, to construct a netting that cannot be broken through by the larger torpedoes at short range, especially by such as are fitted with "nippers," or "cutters," designed for the very purpose of cutting through such nets. It is probable, therefore, that the best and surest protection must take the form of efficient defense, which, in the daytime, consists of a sharp lookout and the ready and accurate use of rapid-fire guns, and at night the same supplemented with a proper use of powerful search lights. By using these instruments with care and precision it can be made almost impossible for any torpedo craft to creep near enough to do any harm.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Peace Conference.

THE world was taken by surprise last summer when, on August 24th, the Czar of Russia invited the ruling powers to participate in an international conference for the purpose of considering the best means of securing universal peace. The circular, which was issued simultaneously to the foreign representatives accredited to the court of St. Petersburg, was simple in form and general in character. It was the expression of the kindly impulses and the earnest convictions of a sovereign who felt that there rested on him a heavy burden of responsibility. It was worded probably by the Russian Minister of Foreign Affairs; but the inspiring idea is that of the man, the young husband and father, Nicholas II, rather than of the statesman, Count Muravieff. It dwelt on the injuries suffered by the countries of Europe on account of their ever-increasing armaments, and proposed that a halt should be called in these incessant preparations for war.

A few months elapsed. It became known that the invitation would be generally accepted, and the subject was freely discussed by the press. Public sentiment appeared to be in favor of the proposed conference; but sober second thought revealed the difficulties that the delegates must encounter, and moderated the hopes which had been kindled by the announcement that the greatest military power in the world sought to promote peace. In the middle of January the Czar issued a second circular, in which the writing of Count Muravieff could plainly be traced between the lines. He indicated means for carrying out the original idea, now somewhat modified, and urged the necessity for putting a stop to the continually increasing armaments. This time he had more specific proposals to make, and he marked out the limits within which official discussion was to be confined.

He suggested that the conference should consider eight propositions, which resolve themselves into four groups: (1) that for a fixed number of years armed military and naval forces should not be increased, and that the aim should be to reduce them; (2, 3, and 4) that the use of new weapons, ammunition, explosives, submarine torpedo boats, and vessels with rams should be prohibited or restricted; (5, 6, and 7) that the laws and customs of military and naval warfare should be rendered more humane; and (8) that the principle of arbitration should be accepted, and means for its application should be considered. He concluded by stating that all questions concerning the political relations of states, as at present established by treaties, must be "absolutely excluded" from discussion. It was thought best that the conference should not sit in any one of the great capitals of Europe, such as St. Petersburg, London, Paris, or Berlin; and The Hague, the capital of the young queen of Holland, has been appointed as the place of meeting. It is expected that the invited delegates, 28 or 30 in number,

will assemble there on May 18th, of the current year.

What will they do? What *can* they do?

They cannot abolish war, nor do away with the necessity for armies, which are the national police, prepared to check breaches of the public peace. They cannot remove all sources of national irritation, satisfy all legitimate or illegitimate national ambitions, or quench the passions of jealousy and revenge, which grow as lustily in the national as in the individual heart. They can and will exert a powerful moral force in favor of peace and good will among nations; their presence for such a purpose will testify to the growing spirit of mercy and justice; and some practical work may be done that may diminish the causes, the chances, and the evils of war.

A consideration of Count Muravieff's eight propositions makes it evident that two only are of crucial importance, namely, the first and the last. The second group, 2, 3, and 4, can hardly be regarded as practical. If armies and navies are to exist, it cannot be supposed that the results of discoveries and of inventive genius will be neglected in connection with their equipment. If an improvement can be devised in the machine gun, it is contrary to reason and to the progressive tendency of the present day that a government should replenish its stock with an article become old-fashioned, which will do its work less effectively than the newer weapon. France is making costly experiments with submarine torpedo boats, hoping thus to adjust the disproportion between her own navy and that of Great Britain in the event of war. Will she see her labor thrown away? Or will other countries consent to see her possessed of a means of attack of which they may not avail themselves? If the submarine torpedo boat is to be ruled out, why not also the torpedo itself, which, when new, was ranked with the concealed weapon of the assassin?

There are not likely to be great differences of opinion with regard to the third group, 5, 6, and 7, which only extends the sphere of established regulations; and progress will probably be made in this direction. Weapons have become more deadly, and slaughter in war more wholesale; but civilized nations respect the Red Cross Society, and wounded friend and foe receive care and kindness alike.

The vital points suggested for discussion are disarmament and arbitration.

The proposal for disarmament comes strangely from the so-called autocratic ruler of the greatest military power in the world.

The Russian Empire is described as lying "within a ring fence, which has very few gateways." She has an army of more than 3,000,000 men, and a rapidly increasing navy. During the months that have passed since the Czar's first circular was issued, military preparations in Russia have been pushed forward with feverish activity, and many new recruits have been enrolled. Is it possible that this enormous force is maintained for purposes of defense and of internal order? Or is it being enlarged only in order to retain its present superiority over the growing armies of other European countries? Its existence is a standing menace to all countries that come in contact with Russia in Europe or in Asia, and goes far to justify the maintenance of large armies among her neighbors. During the past thirty years she has gathered in territory from the east and from the south with both hands, and with an eagerness beside which John Bull's traditional land hunger is moderation itself! And her statesmen announce their belief in her destiny as the future ruler of the whole of Asia. The most effective proposal of peace on the part of Russia would be a cessation of the military preparations that can suggest only a future policy of aggression corresponding to that of the past. Example is better than precept.

No shadow of doubt has been thrown on the sincerity of the Czar; but, nominal autocrat though he may be, he acts through and with the advice of his ministers, whose duty it is to advance the interests of their country. If they believe in the policy of expansion, rather than in the consolidation, the development, and the enrichment of their enormous empire, they will endeavor to use the wishes of their imperial master for the accomplishment of their own ends. If the Powers were pledged to a ten years' peace, during which time armaments and consequent military taxation should receive no addition and might be diminished, how the resources of Russia would increase, as her tax-paying classes became more prosperous; what sums the government might expend on ship canals, on docks, on the merchant marine, on railways already projected to the east and south, which, at the end of the term, would control China and the approaches to India! Railways and other industrial works promote the arts of peace, but they are also most important factors in war.

It has been proposed that all armies

should be proportionately reduced. But who shall decide the scale of the reduction? who weigh the comparative value of the respective forces, and the needs of the various nations? Great Britain has to protect more than four-fifths of the world's commerce, and has colonies in every quarter of the globe; what proportion shall her navy bear to that of Russia or of Germany, with their limited coast line? or to that of France, with her small merchant marine? Shall armies be proportioned to the size of the home population, or shall colonists and subject peoples be reckoned also? Shall the bone and sinew of the races be taken into consideration, and one gigantic Pomeranian or one British grenadier be accounted equal to two Italians or to three Chinese? Shall the size of the remodeled armies correspond to those already existing? Where, then, would the United States come in, with her few troops, barely sufficient to police her home population, yet now reluctantly assuming the share of "the white man's burden" which circumstances have forced upon her? Is she to be debarred from increasing her forces?

In the direction of arbitration, more than in any other, it is believed that good results may ensue from the proposed conference. Count Muravieff, speaking for the Czar, qualifies his suggestions about arbitration by a very important phrase: "the employment of arbitration *in cases lending themselves thereto.*" What room is here for differences of opinion! What tribunal is to decide whether or not a case does not lend itself to arbitration? To lookers-on the quarrel between the United States and Spain was preeminently one that might have been settled by arbitration. America demanded aloud justice for oppressed and mismanaged Spanish subjects in Cuba; deep down in her heart she vowed that Spain should "remember the Maine!" and although arbitration is in line with American history and methods, she refused it, and in face of a strongly protesting minority she imperatively demanded war. Nor would any international tribunal, however highly esteemed, have been allowed to decide for Great Britain and France the threatened quarrel over the Fashoda incident at the end of the recent war in the Sudan.

While human passions and national rivalries exist, it is beyond conception that a court of arbitrators can be entirely trusted as disinterested, unbiased, and fair in all its decisions. Some controversies can be settled only by war; but if all will agree that international differences must first be brought before a court of arbitration, even though that court be not clothed with power to enforce its decrees, the pause necessary for its work will sober the passions of a people, and give them time to reflect on the terrible results of modern warfare as regards both life and property. More cannot be expected until the idea of arbitration has become part of the established order of things. And perhaps more cannot yet be desired; for such a court, endowed with coercive power, would hold the destiny of the nations, especially of the smaller and weaker ones, in the hollow of its hand. In short, it would partake of the nature of a gigantic trust, to the detriment of self-government, which should be an inalienable right.

STEPPING STONES IN THE ART OF COOKING.

Mrs. Henry Esmond.

Step IV: The Making and Baking of Cakes.

IN THE first three steps of this series of lessons, we discussed what are, broadly speaking, the three principal and fundamental methods of cooking foods, regardless of all special preparation of the food itself. In this lesson we will take up the subject of preparing and baking cakes.

Cake is a mixture of some of the following **materials**: **eggs**, butter, sugar, flour, spices, **milk**, **water**, **baking** powder, chocolate, or **fruit**. Many cakes to which different names are given are in reality the same except for the flavorings, but there are two distinct *kinds* of cake, namely, sponge cakes and pound cakes; the latter are made *with* butter, the former without.

To be successful in the art of cake baking, it is necessary to thoroughly understand the regulating of the fire and oven; for instance, it is no use attempting to bake a cake just after the fire has been filled up with fresh coal, or when it is getting low; the fire must

be in a condition to last undisturbed throughout the time required for the baking. The heat of the oven should be moderate—so that you can bear your hand in it—otherwise the cake will be burned on top, and remain uncooked inside.

The time required for the baking varies with the kind and size of cake; layer cakes and cup cakes require 15 minutes, in a rather hot oven; loaf cakes requires from 30 minutes to 3 hours, according to thickness, but the oven should not be quite so hot.

When making cake, try always to make it light; this is done by beating in as much *air* as possible. Sift the flour several times, to loosen and lighten it, and beat the eggs until filled with air and quite stiff. Mix the ingredients with care so as not to break the air bubbles, otherwise the air—or some of it—will escape, and the cake will not be as light as it should be. Where the mixture contains few eggs, use baking powder to make the cake rise.

To commence the baking, place the cake at the bottom of the oven, where the heat is less than at the top. As the mixture becomes heated, the air in it expands and the moisture it contains is turned to steam; both of these, in trying to escape, push against the walls of the little cells inside, and the cake rises. Now, if the heat of the oven is not too great, these walls will become set, and the air and steam will escape very gradually through the top of the cake, leaving it light and spongy; but if the oven is too hot, the top will become brown and hard, sealing up the inside of the cake, and the air and steam will be unable to escape; the walls of the cells will then remain moist, and the top of the cake, being heavy and hard, will fall in and the cake will be spoiled. A cake should not be baked so long that the inside becomes perfectly dry; a very good way to find out if the inside is done is to stick into the thickest part a broom straw or wire skewer; if dry when removed, the cake is done.

In baking loaf cake, divide the time required into four parts, and look at the cake at the end of each part. Always open the door of the oven very gently, because any violent jar or vibration will make the cake fall. At the end of the first quarter the cake should have begun to rise around the edge, but should not be brown on top at all. The next time it is looked at, it should have risen well around the edge and be just beginning to brown at the center. During the last half of the time, it should become a golden brown all over and should shrink a little from the sides of the pan.

Sponge cake is made almost entirely of eggs; these should be perfectly fresh and cool, or they will not beat up stiff. The yolks and whites should be beaten separately. Beat the yolks of 5 eggs until they are thick and creamy; add 1 cup of fine granulated sugar, beat again and add the juice of half a lemon. Add to this 1 cup of sifted pastry flour and, last of all, fold in the whites of the eggs which have just been beaten until very stiff. This folding is done by cutting through the middle of the mixture and passing the spoon along the bottom of the bowl, bringing it up at the side and folding in the contents just as you do the whites of the eggs in an omelet. Repeat this until all the whites are mixed in, but be careful not to break the air bubbles. Bake in a deep pan for 1 hour, and when done turn the pan upside down on a wire tray and leave to cool. Should the cake be removed from the pan before it has cooled, and be set right side up, the top, being heavy, would naturally fall in and make the cake soggy.

In making butter cake, fewer eggs are used and the cake is more solid and richer, though not for this reason *heavy*. If much butter is to be used, it is advisable to wash out the salt, as salt will make the cake fall. Have the bowl slightly warm, and with a wooden or silver spoon beat the butter until light and creamy; then add the sugar and beat again until almost white. Beat the whites and the yolks of the eggs separately; add the yolks to the sugar and then beat again. Sift and measure the flour and add the baking powder (allowing 1 teaspoonful to every cup of flour); put the flour and the baking powder into the sifter and sift part into the first mixture; add a little milk, then more flour, and fold this in carefully. Never beat cake after adding flour, as it will make it too solid and close-grained. When all the milk and flour have been put in, add the flavoring and, last of all, the whites of the eggs, just beaten stiff; fold them in carefully, and bake in any desired shape. If fruit is to be used, sift a little flour over it before mixing with the other ingredients, as otherwise it is apt to stick together and sink to the bottom of the cake. When making a spice cake of any kind, mix the spices with the flour and baking powder; then they will be evenly distributed. It is always best to line the pan with paper; there is then no danger of the bottom of the cake burning.

GOOD SCHEMES

A MARKING-OUT SCHEME.

W. C., Providence, R. I.

In Fig. 1, a is a ring in which there are six holes which do not go through; to mark out plate b so that when drilled the holes in it will be fair with those in a, proceed as follows: Fit a piece into the center hole of the drill table, and into this drill a hole to receive pin P, Fig. 2, the same diameter as the holes in a. Now clamp a and b together,

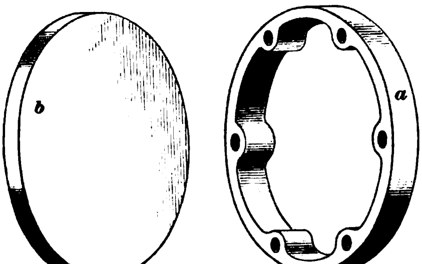


Fig. 1.

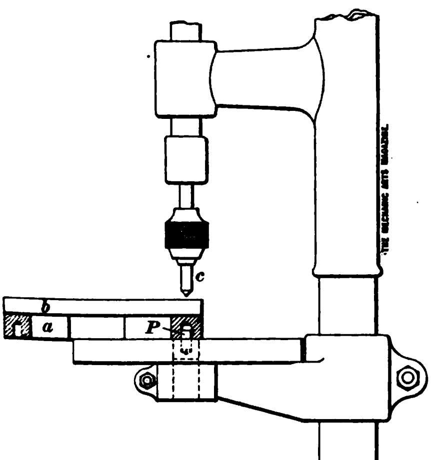


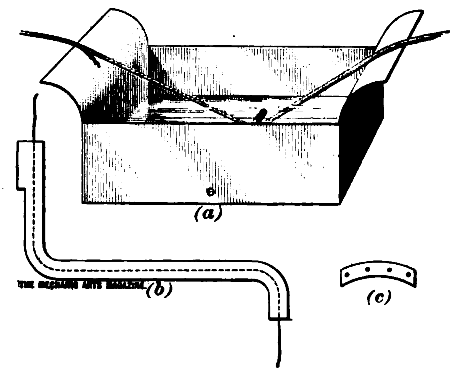
Fig. 2.

with the holes in a outwards, and, as shown in Fig. 2, place upon the drill table with a hole over pin P; then, with a center punch in the drill chuck, come down on b and thus mark the centers of the six holes; mark out in the usual manner, and drill. It is, of course, important that the drill table be securely clamped in position before drilling the hole for pin P, and not disturbed before all the required centers have been marked.

FOR CORE VENTING.

Ed. J. Roy, Belleville, Ont.

For small cores I know of nothing better than the scheme shown in the accompanying sketches. The core shown at (b) and (c) is so small and delicate that it is almost impossible to vent it in the ordinary way, but as I go about it, it is a simple matter. I make a small tin pan, as shown at (a), about 4 in. $\times$ 2 in. $\times$ 1½ in. deep. Near the bottom of this pan I fix a small cross-bar, leaving just enough space between it and the bottom to allow a coarse string or cord to pass. After placing the string in position, I fill the pan with wax, melt it, and draw the string through; the waxed string quickly cools, and I cut it into the desired lengths and use it just as ordinary core wires are used. When



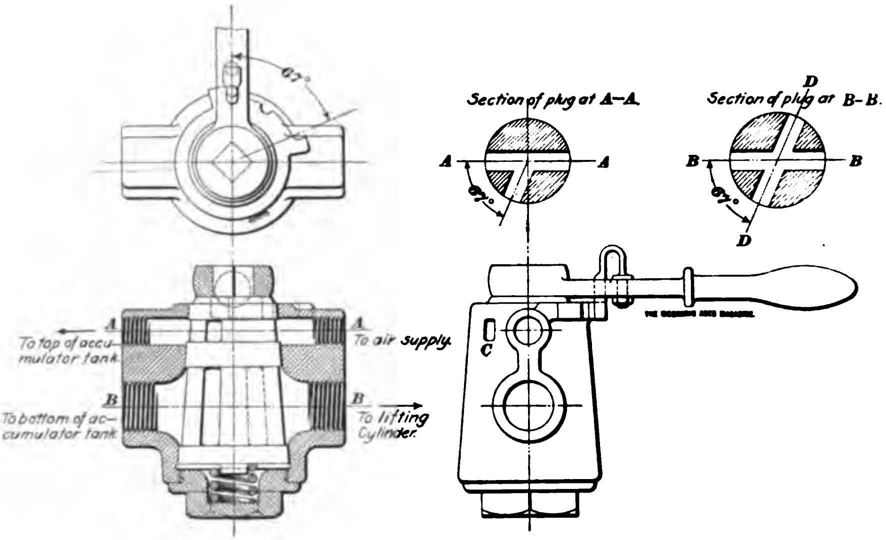
the cores have been baked, the strings are easily withdrawn, and they leave fine, clean vent holes. Cores that are vented in this manner can often be made solid, when otherwise they would have to be made in halves and afterwards pasted together.

A HYDRO-PNEUMATIC VALVE.

S. Edward Beeler, Altoona, Pa.

The valve illustrated herewith is designed to use in connection with elevators operated by compressed air. The pressure is transmitted to the lifting piston by water, thus obviating the necessity of a lock on the elevator, as water does not spring when the load is removed, as is the case when air alone is used. In connection with this valve, it is necessary to use an accumulator

tank, in which the compressed air transmits its pressure to the water; this tank must hold more than enough water to fill the cylinder, as well as all connecting pipes. The action of the valve is as follows: When the handle is in the position shown, the air passes through *A A* to the top of the accumulator tank, and forces water through *B B* to the

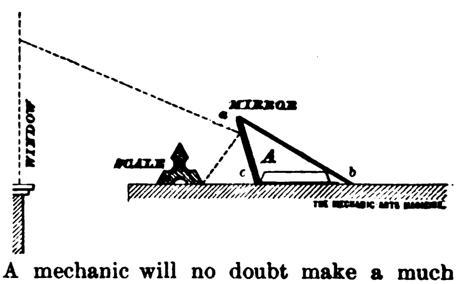


lifting cylinder. To lower the elevator, the handle is moved through an angle of 67°; in the new position the air is cut off from the air supply, but the air over the water in the accumulator tank is free to escape through port *C*, and the water in the lifting cylinder drains back to the accumulator tank through *D D*, which is then in line with *B B*. To stop and to hold the elevator in any position, the handle is placed at half throw; this closes all the ports, so that no water can get either to or from the lifting cylinder.

TO MAKE THE DARK SIDE BRIGHT.

Theo. P. Perkins, Boston, Mass.

WE ARE OFTEN advised to look on the bright side of things, but sometimes it is far from easy to do it. Take the case of a draftsman that works at a table lighted from one side only; it is sometimes painfully necessary for him to look on the *dark* side of the T square scale or triangle, and the darkness or semi-darkness he finds there is very annoying. The enclosed sketch shows how he may brighten these dark sides, by means of the little device shown at *A*. The thing may be done in various ways; if the reader will take a white card and hold it so as to reflect the light from a window behind him, he will be surprised at the additional amount of light he gets; but if he uses a mirror glass, the improvement will be still greater. My "reflector," as I call the whole thing, is made of cardboard bent so as to form a triangular box *a b c*; the mirror is secured to side *a c*, and inside the box, on the base *c b*, a piece of sheet lead is fastened to weight the whole thing down and prevent it from toppling over. The angle that the mirror should make with the drawing surface must be determined by trial; mine is about as shown.



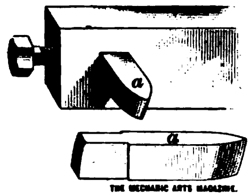
A mechanic will no doubt make a much better and more durable device than this, but the principle will be the same.

A USEFUL LATHE TOOL.

Prentice, Canada.

ENCOURAGED by the acceptance of my last "good scheme," I herewith submit a drawing of what I have found to be a very useful little tool. I know it appears simple, but I know, too, by actual experience, that it is a great time saver, and even the oldest turners

I have worked with have never seen one similar, and they fully appreciate it. I use it mostly on brasswork and cast iron in boring, and for threading and for facing both faces of the holes. The tool *a* is made of $\frac{3}{8}$-inch square steel, and is secured to the boring bar in the manner shown.

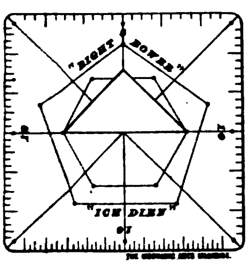


In threading $1\frac{1}{4}$-inch elbows I did thirty-four—faced, bored, and threaded—without taking the tool out of the rest. I believe there are many turners that would be glad to try it, and I am sure they will find it useful.

RIGHT BOWER.

S. K. Kirby.

I ENCLOSE a little drawing instrument I have had made that I have christened "Right Bower." (The illustration is half size; the thing itself is 3 inches square, is made of celluloid, about $\frac{1}{32}$ inch thick; the 45° triangle is cut out; the small circles at the corners of the hexagon, etc. are holes just large enough to prick through with the point of a sharp pencil.) It is intended to be of assistance to the draftsman when working up little details on small drawings, instead of using T square, triangles, etc. The edges being graduated, it takes the place of a scale for small work. By means of the small holes, circles can be divided into 3, 5, 6, 8, 10, 12, 16, etc. parts, and various shapes can be laid out.

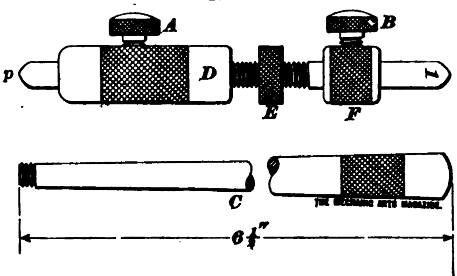


In sketching, it is a great help, for it fulfils the purposes of T square, set-square, 45° triangle, and scale, and the more one uses it the more one finds out can be done with it. Its size is very convenient, being just right to carry in the vest pocket. With the "Right Bower," a small pair of compasses, and a lead pencil, almost any small detail can be accurately laid out, without the help of either a drawing board, T square or any other instrument. I think it probable that a larger size, say 6 inches square, might be preferred by some.

INEXPENSIVE INSIDE MEASURING TOOL.

S. B. Bragg, Providence, R. I.

ENCLOSED sketch represents a simple, inexpensive, inside measuring tool that I think will find favor with some of the readers of Good Schemes. The main part *D* I call the *holder;* it is $\frac{1}{2}$ inch in diameter and $1\frac{1}{4}$ inches long; at one end it carries a hardened point *p*, and at the other any one of a set of rods, of which No. *1* is shown in position; it is drilled and threaded its whole length, and allows the rod $\frac{1}{8}$ of an inch end movement. *E* is a check-nut, which, after the rod has been set to the required length, is screwed up tightly against *D*. *F* is a collar that fits every rod; its purpose is to assist in turning the rod, and it is fixed in position by the knurled-headed screw *B*. *C* is a handle that may be screwed into *D* in place of *A* when it is desired to measure the diameter of a long, small hole. The table



shows the number and sizes of the rods in my set, together with the lengths that can be measured. The rods are $\frac{3}{16}$ inch in diameter.

Number of Rod.	Length of Rod. Inches.	Length Measures. Inches.
0		
1	$2\frac{7}{16}$	$3\frac{5}{16}$ - 4
2	$3\frac{1}{8}$	4 - $4\frac{11}{16}$
3	$3\frac{13}{16}$	$4\frac{11}{16}$ - $5\frac{3}{8}$
4	$4\frac{1}{2}$	$5\frac{3}{8}$ - $6\frac{1}{16}$
5	$5\frac{3}{16}$	$6\frac{1}{16}$ - $6\frac{3}{4}$
6	$5\frac{7}{8}$	$6\frac{3}{4}$ - $7\frac{7}{16}$
7	$6\frac{9}{16}$	$7\frac{7}{16}$ - $8\frac{1}{8}$
8	$7\frac{1}{4}$	$8\frac{1}{8}$ - $8\frac{13}{16}$
9	$7\frac{15}{16}$	$8\frac{13}{16}$ - $9\frac{7}{16}$
10	$8\frac{5}{8}$	$9\frac{7}{16}$ - $10\frac{1}{8}$
11		
12		

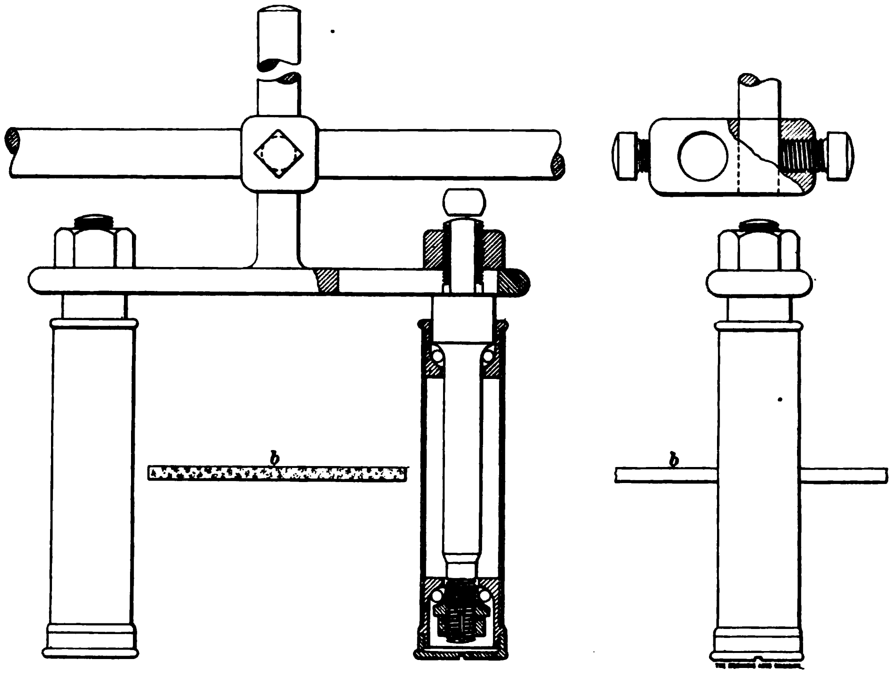
A BALL-BEARING BELT-SHIFTER.

J. R. Nichols, Lachine Lock, Que.

THE BELT SHIFTER illustrated in the accompanying drawing is the invention of Mr. Charles Dawson and Mr. Eli Addler, of The Dominion Bridge Co. They have given me

permission to describe it for your Good Schemes columns.

It is necessary in bridge shops to have a great deal of headroom, and this makes the belts that drive the machines very long. It was found that a considerable saving was effected in the belt account if cotton was used instead of leather, but it was soon discovered that the cotton belts were quickly frayed at the edges by the belt shifters; especially was this the case on planers and other machines, where the belts were frequently shifted from one pulley to another. To prevent this excessive wear on the edges of the belts, the gentlemen referred to designed the ball-bearing shifter shown. In both figures, *b* is the belt, and the construction of the forks is clearly shown in the sectional view of one of them. We have this shifter in use in all parts of the shop; it works splendidly, and now instead of the belts fraying, the edges are soon rolled smooth and are in better condition after being in use three months than when they are first put on. It is just as good for leather belts too, there being no sign of edge wear on a planer belt after being in constant use for six months. The shifter is rather expensive, of course, but the saving in the belt account soon exceeds the extra first cost.



BLUEPRINT EXPOSURES.

Wm. P. Morrison, Halifax, N. S.

In making blueprints it is very difficult for a beginner to tell when the paper has been exposed long enough. It is also hard for any one who has not made any prints for some time to tell by the change in the color of the paper when the first print is finished; and even to those who are well up in the art it is not an easy matter, when making a number of prints, to get them all of the same shade of blue. For the benefit of those who may be thus situated, I would like to suggest the following scheme, which I have often employed with success. I do not claim that the scheme is a new one, but, so far as I am concerned, it is original.

Get a small frame, such as those used by photographers, about 3 in. × 5 in. (no description of this frame is necessary), cut a piece of tracing cloth the size of the frame, and on the cloth draw a number of lines with India ink *1*, *2*, *3*, *4*, etc. When you put your paper in the large frame to be printed, put also a number of pieces of blueprint paper in the small frame, one piece under each line on the tracing cloth. Expose the prints in both frames to the sun at the same time. Have a dish of water handy, and from time to time

open the back of the small frame, take out one of the pieces of blueprint paper and wash it. As soon as you get a piece that when washed is a dark blue with a clean, white line, then you know that your print is finished. When making more prints, go through the same process. In order to get all the prints of the same shade, leave the strips of test blueprint paper in the dish of water (the reason for leaving the paper in the water is because the color changes when dry), and when making other prints keep trying your test strips until you get one of the same shade as your test strip in the dish of water. There is a black process paper, which is now coming a good deal into use. It is exposed to the sun and washed in water the same as the blueprint. When making blackprints put strips of black process paper in your small frame.

I hope that some one will find the scheme useful.

[The scheme mentioned above is an old one, and we publish it only that we may comment on it. We have used both methods, and feel competent to express an opinion as to their merits. The method of time exposure is very much harder to learn and very much less satisfactory than the method of judging by color. When printing by time exposure, the conditions are seldom the same, except in the summer time, and long practice is necessary in order to judge when the print has been exposed long enough. The reflection of light from buildings, from the ground, or from the snow in winter, will all exert their effects on the length of time that the print must be exposed. If the weather is slightly cloudy, this will also have its effect, and the time will vary according to the clearness of the sky, according to the angle at which the light strikes the paper, and to numerous other causes, which can only be discovered after long practice. Then, too, the person taking the print must be in constant practice, or else he will forget. The length of time that the print must be exposed also depends on the paper used, whether it is fresh or old, and whether it is boughten or prepared. All the above and much more will affect the length of time that a print should be exposed. In order to judge by color, however, it makes no difference what the character of the day is, whether it is light or cloudy, or what; and one can soon become very expert in taking prints by this method.—ED.]

DRAFTING-ROOM LUXURIES.

W. H. W., Toledo, Ohio.

HEREWITH I send you a couple of "drafting-room luxuries," which I think may do for

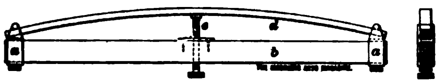


FIG. 2.

your Good Schemes columns. Fig. 1 shows a drawing-board extension that was designed by the former head draftsman of this office. It consists of a brass casting A, clamped to the board by the setscrew B, and holding the wooden bar C, which is of any desired length. The drawing illustrates *one* of the uses of the instrument; another is to locate the vanishing point in a perspective drawing. Fig. 2 shows an adjustable curve, which, although rarely seen outside of ship-drafting rooms, ought to become a favorite with every draftsman. The small brass castings a are made to slip over the ends of the bar b and to loosely hold the wand d, which is then pushed into the desired curve by the adjusting screw c. In this office we have bars and wands of several lengths, all fitting the same set of castings and adjusting screw. By this means we are able to draw curves of different depths, using the longer wands for the shallower curves. The bars are of pine and were made by one of the patternmakers.

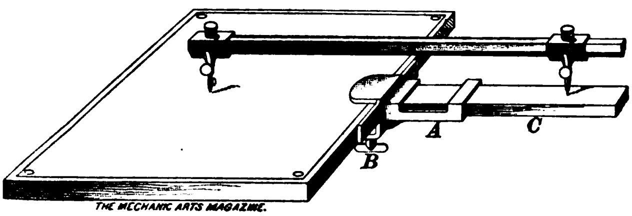


FIG. 1.

CALIPER SETTING.

Prentice, Canada.

THE SCHEME described by C. C. in the March number is good, but I think the handiest way to use the paper is to lay it *on the piece to be measured* (in the hole or on the shaft, as the case may be) and thus make the allowance for the desired kind of fit while calipering, instead of afterwards, as by his method.

TRADE NOTES

ONE-HALF-HORSEPOWER ENGINE FOR AMATEURS.

B. R. Wicks, of Bridgeport, Conn., offers complete sets of castings, steel parts, and screws with one set of blueprint working drawings of the Wicks ½-horsepower high-speed, slide-valve, side-crank, horizontal engine. This would appear to be an excellent opportunity for the amateur that wishes to build a small engine for his own use. The general design of the engine is shown in the plan view and side elevation in Fig. 1, and one sheet of the detail drawings is reproduced in Fig. 2; actual size of sheet, inside the marginal line, is 19 in. × 12½ in. Mr. Wicks will also supply the drawings alone.

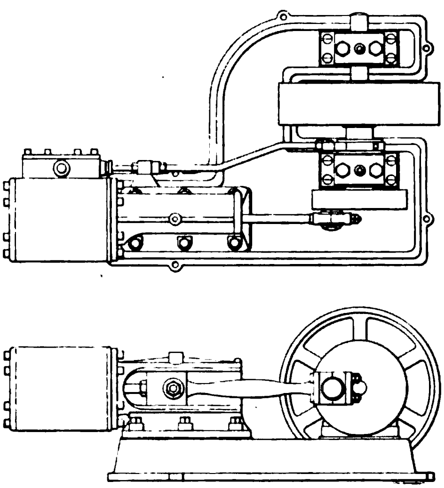


Fig. 1.

INJECTORS.

We have received the catalogue of the American Injector Company, corner Congress and Seventh Streets, Detroit, Mich. In addition to a full description of the various goods manufactured by them, a great deal of valuable information about the operation and management of injectors is contained in their catalogue. A long list of practical engineer's examination questions and their answers, together with a number of valuable tables and other data, is appended. It is a catalogue that is well worth the close study of any one contemplating the purchase of an injector, or in need of practical information concerning the putting in, adjustment and management of same.

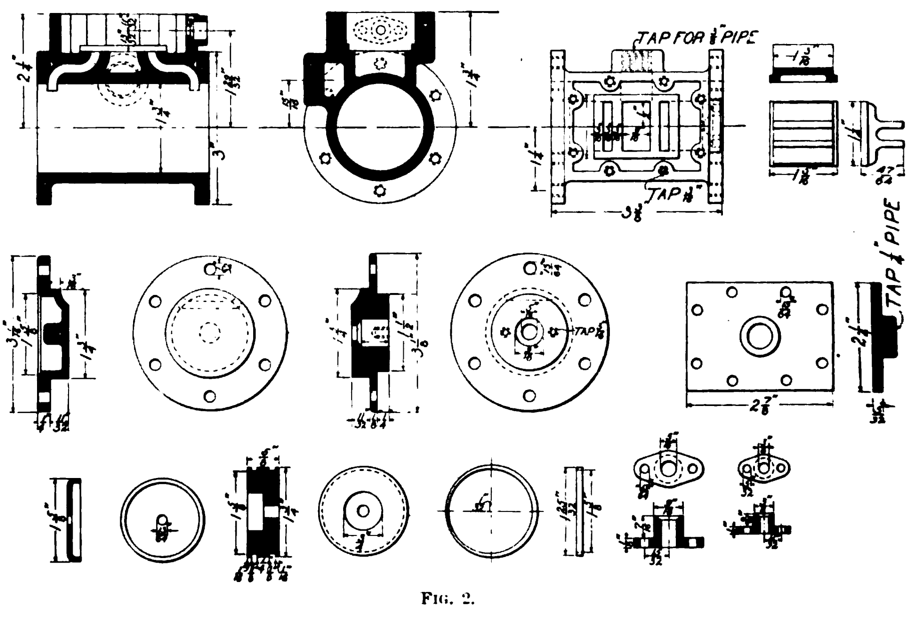


Fig. 2.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

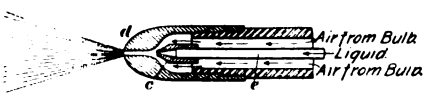
6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

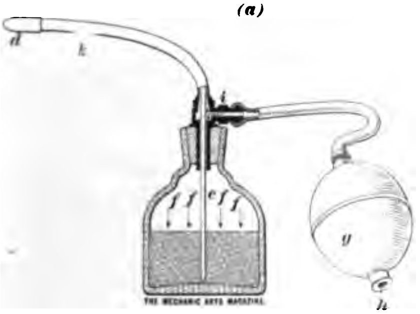
(96) What is the principle of action of the atomizer used by people who suffer from catarrh or other affections of the throat or nose?

G. M., San Francisco, Cal.

ANS.—The principle is similar to that of the Giffard injector, as you will gather from the following: The general construction of the Davidson Rubber Co.'s atomizer is shown at (*b*), in part section; *g* is a rubber bulb fitted with a valve *h*, which allows air to get



(*a*)



(*b*)

into the bulb but prevents its escape. Upon squeezing the bulb, the contained air is forced through *i*, and, as indicated by the small double-headed arrow, the air travels in two directions, part of it causing an increase of pressure in the bottle, the downward result of which is to force a small quantity of the liquid up the fine tube *c*, and the rest passing up around tube *e* but inside tube *k* until, as shown in the enlarged sectional view at (*a*), it passes around and beyond the small nipple *c* and out through the fine opening in *d*. As the air passes out at *d*, it "sucks" the liquid that has reached nipple *c* in tube *e*, and the air and the liquid are discharged together in the form of a fine spray. When the bulb is squeezed, air is the first to be discharged but it is immediately followed by the sprayed liquid. The space above the liquid in the bottle serves as a reservoir of compressed air; it is this that maintains a nearly steady spray while the action of the bulb is intermittent; the air that passes into the bottle when the bulb is first squeezed eventually escapes at *d* while the bulb is refilling through valve *h*.

***

(97) Has there been any process made known recently by which copper can be tempered in the same sense that steel is tempered? If so, by whom was it discovered, and what is the process?

W. H. E., Lincoln, Neb.

ANS.—A search through the "Patent Office Gazette" discloses three patents on hardening copper in the last 10 years; they are as follows: No. 509,619 to Philip Helbig, granted Nov. 25, 1893; 566,462 to John Miller, granted Aug. 25, 1896; 587,861 to Jakob Reuter, granted Aug. 10, 1897. The processes are but briefly described in the "Gazette." You can, however, obtain a copy of any patent with a full description of the process. Address Commissioner of Patents, Washington, D. C. Each copy costs 5 cents. In brief, the processes are as follows: Helbig's—Melt copper, treat with glass and subcarbonate of iron, and finally incorporate antimony with copper thus treated. Miller's—Melt copper, add carbon, next add horn and blood of animals, and then add tin. Pour into molds, cool, and finally compact by pressure. Reuter's—Enclose the piece of copper in a covering of clay and saturate with vinegar; subject the clay containing the copper to a high degree of heat, and finally submerge the whole in water.

***

(98) (*a*) Given, a gear of 100 teeth driving a gear of 33 teeth; on the same shaft is a gear of 25 teeth driving a gear of 75 teeth, which in turn drives a gear of 20 teeth, having a worm on the same shaft that drives a worm-wheel of 100 teeth, and on this shaft is a drum 20 inches in circumference. How far will a point on the drum travel during one revolution of the first gear? (*b*) If a 33-tooth gear were replaced by a 50-tooth gear, what change would it make?

W. S., Titusville, Pa.

ANS.—(*a*) First find what part of a revolution the drum will make during one revolution of the 100-tooth gear; this will be

$$\frac{100 \times 25 \times 75 \times 1}{33 \times 75 \times 20 \times 100} = \frac{5}{132}.$$

This represents, on the surface of the drum, a distance of $\frac{20 \times 5}{132} = .758$ inch. (*b*) If you substitute for the 33-tooth a 50-tooth gear, you will increase this distance in the proportion of 50 to 33, and the distance that a point on the drum will travel during one revolution of the 100-tooth gear will be 1.148 inches.

***

(99) Kindly help me in the following matter: I wish to use hot air for a certain purpose; if I run compressed air into a reservoir, inside of which I have coils of steam pipe fed with steam at a pressure of 125 pounds per square inch, what air temperature shall I get? The air will be fed in at the bottom of the reservoir, and will pass up through the coils, and be used gradually. Can I use the air over and over again by running it back into the reservoir, supposing the pressure to be 80 pounds? Can I heat air as hot as 360° and hold it there within 10°?

F. R. N., Akron, Ohio.

ANS.—The temperature of steam at 125 pounds per square inch gauge pressure is about 352°; therefore,

it is impossible to heat the air above 352° under the most favorable circumstances. The temperature that you can attain may be arrived at approximately by the following formula, which is a modification of one given by Mr. J. A. Kinealy for air at ordinary pressures:

Let S = square feet of heating surface in coil;
W = weight of air used per hour;
t_0 = temperature of steam in coil;
t_1 = temperature of air entering heater;
t_2 = temperature of air leaving heater.

Then, $$t_2 = (t_0 - t_1)\left(.369 + \frac{2.63\,S}{W}\right) + t.$$

Thus, suppose you use 10 pounds of air per hour per square foot of heating surface; the temperature of the compressed air is originally 80° F. and the temperature of the steam is, as above, 352° F. Substituting these values in the formula

$$t_2 = (352 - 80) \times \left(.369 + \frac{2.63}{10}\right) + 80° = 252°, \text{ nearly.}$$

You can, of course, use the air over again if you compress it; otherwise, you cannot.

***

(100) What are the formulas used for figuring the size of the inlet and the exhaust valves of a four-cycle gas or gasoline engine?

A. R. T., Titusville, Pa.

Ans.—Each maker doubtless has his own rule or formula. The following rules agree well with good practice:

Area of inlet valve = .12 × area of piston.
Area of exhaust valve = .16 × area of piston.

Denoting by d and d_1 the diameters of inlet and exhaust valves, respectively, and by D the diameter of the cylinder, these rules reduce to the following formulas:

$$d = .346\,D.$$
$$d_1 = .4\,D.$$

***

(101) What size stringers will be required on a bridge in which the bents are 12 feet center to center, to carry a 28-ton locomotive of the mogul type? We use exclusively yellow pine; if you are acquainted with the strength of this wood, I would like to know if 8″ × 10″ stringers would be strong enough for such an engine.

A. W. S., Chatawa, Mich.

Ans.—It is impossible to answer this question properly without knowing the amounts and relative positions of the wheel concentrations, but any reasonable assumption for these would require the stringers to be larger than 8 in. × 10 in. Assuming 27 tons to be supported on three pairs of drivers whose centers are 5 feet apart, 9,000 on each driver, we find that a size of 10 in. × 14 in. will be sufficient for the stringers, if composed of yellow pine.

***

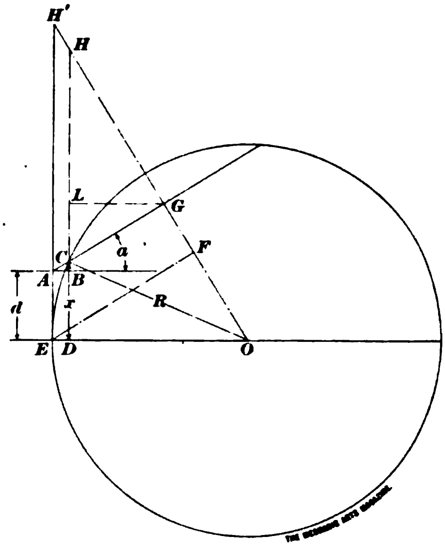
(102) What values are usually taken for the terminal pressures in compound direct-acting pumps, condensing and non-condensing? Also what is a good figure for triple expansion pumps? What limits these values in practice? S. J. B., Holyoke, Mass.

Ans.—With steam pumps as with steam engines, the greatest economy should be obtained when the terminal pressure is reduced practically to the back pressure, say 17 pounds above vacuum for non-condensing engines and 2 to 3 pounds for condensing engines. In practice these terminal pressures frequently cannot be attained without making the ratio between the cylinder volumes excessive. An example will make this point clear. Suppose steam enters the high-pressure cylinder at 110 pound gauge or 125 pounds absolute, and a terminal pressure of 18 pounds is desired. The number of expansions must be 125 ÷ 18 = 7, nearly; that is, the volume of steam in the low-pressure cylinder, intermediate pipes, etc., is 7 times the original volume of the steam in the high-pressure cylinder. If we assume that the volume of steam in the pipes and passages is equal to the volume of the high-pressure cylinder, then the volume of the low-pressure cylinder must be 6 times that of the high-pressure cylinder, and the diameter of low-pressure piston must be $\sqrt{6} = 2.45$ times the diameter of the high-pressure piston, a ratio much greater than it is practicable to use. If we assume a ratio of volumes of 2½, then the number of expansions will be 3½, and the terminal pressure will be 125 ÷ 3½ = 36 pounds, nearly. With triple-expansion pumps it is possible to get a lower terminal pressure, because the ratio of cylinder volumes can be made greater than with compound pumps.

***

(103) Can the distance x be found from the data given in the sketch? If so, kindly give the solution; if not, give reason. E. C. D., Pittsburg, Pa.

Ans.—Draw OG perpendicular to the line AC produced; produce OG to meet DC produced in H, and EA in H'; draw, also, EF perpendicular to OG, and



GL perpendicular to DH. Then, angle $EH'O$ = angle DHO = angle a; and angle $EOH' = 90° - a$. Hence, $FG = d \cos a$, and $OF = R \sin a$.

Therefore, $OG = d \cos a + R \sin a$.

From the right triangle OGC, we have

$$CG = \sqrt{R^2 - (OG)^2}$$
$$= \sqrt{R^2 - (d \cos a + R \sin a)^2}.$$

Again, DL is the projection of OG upon DH, and CL is the projection of CG upon DH.

Therefore,

$$DL = OG \cos a = (d \cos a + R \sin a) \cos a,$$

and

$$CL = CG \sin a = \sin a \sqrt{R^2 - (d \cos a + R \sin a)^2};$$

whence,

$$x = DC = DL - CL = (d \cos a + R \sin a) \cos a$$
$$- \sin a \sqrt{R^2 - (d \cos a + R \sin a)^2}.$$

***

(104) (a) Is there a more exact formula than $\frac{\pi}{4} Dd$ for finding the area of an ellipse? (b) What kind of thermometer is used for ascertaining the

excessively low temperatures obtained by liquid air?
F. H. B., Providence, R. I.

ANS.—(*a*) No; the formula is mathematically exact. (*b*) The thermometer used by Prof. Dewar consists essentially of a coil of fine platinum wire. As is well known, the electrical resistance of a metal decreases as the temperature is lowered; hence, if a law connecting the resistance with the temperature can be established, the resistance, which can of course be readily measured, can be used to calculate the temperature. The calibration of Prof. Dewar's No. 7 thermometer gave the following resistances at different temperatures:

Temperature Degrees C.	Resistance Ohms.	Temperature Degrees C.	Resistance Ohms.
+ 99.1	7.337	− 78.2	3.687
+ 75.3	6.859	− 182.6	1.398
+ 51.4	6.388	− 193.9	1.136
+ 25.7	5.857	− 214.0	0.690
+ 0.7	5.338		

The formula connecting the resistance with the temperature is as follows:

$$(R + 43.958933)^2 = 2.03596488\ (t + 1{,}193.146).$$

***

(105) If a cylindrical tank 10 feet in diameter and 20 feet deep is set on end 25 feet above the ground, and a piece of pipe 20 feet long leads from the bottom of the tank to within 5 feet of the ground, what is the pressure at the end of this pipe?
R. F. K., Sharon, Pa.

ANS.—We assume that you wish to know the pressure at the end of the pipe when the tank is filled with water and the end of the pipe is plugged. The total head of water is 20 + 20 = 40 feet. To reduce the head in feet to pressure in pounds per square inch, we multiply by the constant .434; hence, the pressure is 40 × .434 = 17.36 pounds per square inch, exclusive of atmospheric pressure.

***

(106) State, in the order of their importance, the defects to be guarded against in the following materials: (*a*) cast iron, (*b*) brick, (*c*) stone, (*d*) lumber, and (*e*) wood to be used for piles.
H. E. B., N. Windham, Conn.

ANS.—(*a*) Cast iron is likely to have hidden and small surface defects and air bubbles. It is important also that the parts of a casting be so proportioned that no initial strain may be caused by unequal cooling. (*b*) Brick should not contain an excess of sand, as it is thereby rendered brittle and the cohesion is destroyed. The inspection should guard against overburned, hard, brittle brick, which are generally distorted and cracked, and against soft, underburned brick. (*c*) A good stone should be compact. A freshly fractured stone should show a clear bright surface, with the particles well cemented. When struck with a hammer it should give a clear metallic sound. A good stone should absorb but little water, not more than 5 per cent. in 24 hours. It should be insoluble. To test for solubility, put some crushed stone in a glass of water, let it rest about an hour, and then stir. If the water becomes cloudy, it indicates the presence of soluble materials in the stone. (*d*) In selecting lumber, the most important points are straight grain, freedom from large or loose knots, wind and heart shakes. A freshly sawed surface should be clean and lustrous, with a firm and bright appearance, free from woolly fibers, which indicate lack of vitality. The sap wood should be entirely removed. The wood should appear uniform in texture, and when cut should smell sweet: a disagreeable smell indicates decay. (*e*) Piles should never be less than 8 inches in diameter at the small end, nor more than 18 inches in diameter at the large end. Piles should be straight-grained, should be trimmed close, and should have the bark removed.

***

(107) (*a*) Is the result of a boiler explosion caused by overpressure of steam exactly similar to one caused by there being too little water in the boiler? (*b*) Is there any distinction between the words "burst" and "explosion"?
H. R., Newdale, Manitoba.

ANS.—(*a*) The answer to this question depends on the type of boiler. It may be stated as a general law that the violence of a boiler explosion depends on the quantity of water the boiler contains. With a large body of water, the explosion is likely to be extremely violent and destructive; while if the boiler contains little or no water, the explosion is far less dangerous. In the case of a boiler of the locomotive type, there is a large quantity of water left in the shell when the crown sheet is dry; hence, an explosion due to low water would be nearly or quite as violent as one due to overpressure. With a plain cylindrical boiler, on the other hand, an explosion from low water is not likely to occur until the boiler is nearly empty; consequently, the explosion from low water will be less disastrous than one due to overpressure. (*b*) There is a material distinction between the two words. To "burst" means simply to "rupture." A water pipe bursts when the water freezes; a boiler may be burst when subjected to a hydraulic test. An explosion may be defined as a process—as combustion, decomposition, or rapid ebullition—resulting in a rapid and excessive generation of gases and a sudden and great increase of pressure. In the case of the boiler explosion there is an initial bursting or rupture of a plate or flue; the steam rushes rapidly through the space thus opened, and the pressure being thus suddenly relieved, a quantity of water at boiling temperature flashes instantly into steam, increasing the pressure enormously. This constitutes the explosion.

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(108) (*a*) What is the cost of a complete set of steel straightedges, and what are their lengths, widths, thicknesses, and weights? (*b*) Are there on the market straightedges of any other metal than steel, and why are they made of steel in preference to some other metal? (*c*) What is the cost per pound of aluminum and of platinum? Are these metals ever used for electroplating, and do they wear well? (*d*) What is the best and most serviceable electroplating metal? (*e*) Of what material is the so-called "diamond" point of a glass cutter made? Will it cut steel or other hard metal as it will glass? (*f*) What is the cheapest and hardest metal, resembling aluminum and platinum in color, that will resist the sharp edge of a steel blade? (*g*) If two pieces of the same kind of steel are tempered to the same degree of hardness, and one piece is sharpened to a cutting edge, will it cut the other piece, or will its own edge be dulled, or will neither be affected?
W. S. T., Cornwall, Ont.

ANS.—(*a*) This question is too general. We do not think there is such a thing as a complete set of steel straightedges. They are made in any length, width, and thickness desired. (*b*) Small straightedges have been made of brass. We do not know of any other metal used for this purpose, except steel. The reason steel is used is because it is harder and, consequently, less liable to injury. Steel, also, oxidizes (tarnishes) less readily than brass. (*c*) Aluminum can be purchased for 40 cents a pound, perhaps less, depending upon the quantity. We do not know the present market value of platinum, but it is about the same as that of gold, $20.00 an ounce. We have never heard

of either of these metals being used for electroplating. (*d*) Silver or nickel. Nickel is probably a more serviceable plating than silver, as it oxidizes less rapidly. (*e*) The so-called diamond point of a glass cutter is a diamond. It will cut any material except a diamond. (*f*) There is no cheap metal that will resist the sharp edge of a steel blade; all metals harder than hardened steel are very rare and exceedingly expensive. (*g*) If both pieces are hardened to exactly the same degree of hardness throughout, that is, so that there shall be no soft spots anywhere, neither will cut the other. The cutting edge, however, would be ground off when attempting to cut the bar.

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(109) (*a*) Where can I get a list of all the paper mills in the United States, telling in what towns the mills are located and what kinds of paper they make? (*b*) In paper mills, small scales are used for weighing paper by the square foot. How are these scales constructed, and in what do they differ from ordinary scales? J. H., Crescentville, Ohio.

ANS.—(*a*) In Lockwood's Directory, published by Howard Lockwood & Co., 126 and 128 Duane Street, New York; price, $2.00. (*b*) You can obtain catalogues and information regarding scales from Perkins, Goodwin & Co., New York.

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(110) (*a*) Is the Taylor air compressor, described in HOME STUDY MAGAZINE, June, 1898, a practical machine? (*b*) Is it patented? (*c*) What is the address of the makers? SUBSCRIBER.

ANS.—(*a*) Yes; it is thoroughly practical; write to the inventor, Charles Havelock Taylor, Montreal, Que., Can., and he will tell you of the many that are now in successful operation. (*b*) There are several patents on it; the latest that we have particulars of is U. S. patent No. 618,243, Jan. 24, 1899. (*c*) Mr. Taylor will be glad to answer this question if you write him.

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(111) (*a*) How can glue liquor that has been made from mixed bones and has a turbid appearance be clarified? (*b*) During the process of drying, while spread out on wire netting, the air darkens the glue; is there any way in which this can be avoided? F. W. D., St. Louis, Mo.

ANS.—(*a*) Ordinary glue is clarified with powdered alum, which precipitates the various impurities. Bone-glue liquor is bleached by the action of sulphurous acid produced by sulphuric acid and charcoal. (*b*) We are unable to find any information regarding this point.

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(112) (*a*) What is the correct method of construction for gravel roofs? (*b*) Are they suitable for tropical climates? A. L. L.. Tantoyuca, Mexico.

ANS.—(*a*) In answer to your question we quote some extracts from the specifications used by the Warren-Ehret Company, of Philadelphia, who have had 30 years' experience in the construction of gravel and slag roofs. "The rafters should be near enough to one another to make the roof firm, when planked or boarded, so that it shall not spring under the feet. Tongued-and-grooved lumber is preferable: and in any case the plank or roof boards should be laid closely, making close joints, both at their edges and ends; and should be free from holes or loose knots, and securely nailed to the rafters. Over the foregoing lay full four thicknesses or layers of roofing felt; thus, make the first course, next the eaves, of full five thicknesses or layers of felt. Then lap each successive layer at least ¾ of its width over the preceding layer, firmly securing the felt with tins or cleats nailed on, and thoroughly mop the surface underneath the outer layer of the first course, and underneath each succeeding layer, as far back as the edge of the next lap, with a thin coating of cement, in no case applied hot enough to injure the woolly fiber of the felt. The quantity of felt to be used per 100 square feet of roofing to be not less than 70 pounds. Over the entire surface of the felt thus applied, spread a good coating of cement, amounting in all (including what is used between the layers of felt) to not less than 10 gallons of cement per 100 square feet, heated as before specified, and completely cover the same with a coating of slag, granulated and bolted for the purpose—using no slag larger than that which will pass through a ⅝-inch mesh, and none smaller than that which will be caught by a ¼-inch mesh. The slag should be free from sand, dust, and dirt, and applied perfectly dry, and while the cement is hot. All chimneys and walls that project above the roof should be flushed and counterflushed with zinc or copper The eaves top should be of the same material." (*b*) Yes, if properly laid.

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(113) Kindly tell me of a book that will instruct me on the details of envelope machines. If you do not know of any book, help me in any other way that you can. C. F. H., Burnside, Conn.

ANS.—It is hardly probable that there is any book published on this subject. As most of these machines are patented, you can gain a very complete insight into their details by ordering from the United States Patent Office the whole class of patents on the subject. We advise you also to write to the various manufacturers for catalogues. Many of the firms making bookbindery machines also make envelope machines; a specialty of the latter is made by only one party so far as we know: Martin Ran, 39 Center Street, New York, N. Y.

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(114) (*a*) I have a steam engine of the following dimensions: cylinder, 3½ inches in diameter: stroke, 7 inches; flywheel, 3 feet in diameter, weighing 170 pounds; drive pulley, 20 inches in diameter, 4-inch face; revolutions per minute, 200; feedpipe ⅜ inch; exhaust pipe, ¾ inch; steam pressure 60 pounds gauge. What is the horsepower, approximately? (*b*) What kind of oil is used in boilers to prevent them from corroding? (*c*) Does it injure a boiler to have the engine exhaust into the smokestack? (*d*) Which is the safest boiler feeder—the injector, the inspirator, or the pump? L. B. W., St. Johns, Pa.

ANS.—(*a*) You have not specified the point of cut-off. Assuming this to be at half stroke, your engine should develop about 1¼ horsepower. (*b*) When the corrosive action in the boiler is due to greasy feedwater, mineral oil is sometimes used as a substitute for carbonate of soda. (*c*) No, if you take care to prevent drippings of condensed steam from reaching any part of the boiler; such drippings would be apt to form corrosive mixtures with soot and ashes. (*d*) The pump.

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(115) (*a*) In what manner can the percentage of carbon, of oxygen, and of refuse matter in a given sample of coal be determined? (*b*) Kindly recommend a book on elementary chemistry and also one on gas and gasoline engines. H. A. F., Mont Alto, Pa.

ANS.—(*a*) The answer to this question involves a discussion of analytical chemistry, which would be long for these columns and would probably be of no value to the inquirer. (*b*) "Remsen's Organic Chemistry," price $1.30. "The Gas and Oil Engine," by D. Clerk, price $4.00. These books may be obtained from The Technical Supply Co., Scranton, Pa.

SELF HELP

CONSTANCY ESSENTIAL TO SUCCESS.

ONE of the most gifted Frenchmen, in point of great intellectual endowments, was Benjamin Constant; but, *blasé* at twenty, his life was only a prolonged wail, instead of a harvest of the great deeds which he was capable of accomplishing with ordinary diligence and self-control. He resolved upon doing so many things, which he never did, that people came to speak of him as "Constant the Inconstant." He was a fluent and brilliant writer, and cherished the ambition of writing works, "which the world would not willingly let die." But while Constant affected the highest thinking, unhappily he practiced the lowest living; nor did the exalted standard of his books atone for the meanness of his life. He frequented the gaming tables while engaged in preparing his work upon religion, and carried on a disreputable intrigue while writing his "Adolphe." With all his powers of intellect he was powerless, because he had no faith in virtue. "Bah!" said he, "what are honor and dignity? The longer I live, the more clearly I see there is nothing in them." It was the howl of a miserable man. He described himself as but "ashes and dust." "I pass," said he, "like a shadow over the earth, accompanied by misery and weariness." He wished for Voltaire's energy, which he would rather have possessed than his genius. But he had no strength of purpose—nothing but wishes: his life, prematurely exhausted, had become a heap of broken links. He spoke of himself as a person with one foot in the air. He admitted that he had no principles, and no moral consistency. Hence, with his splendid talents he contrived to do nothing; and, after living miserably for many years, he died worn out and wretched.

The career of Augustin Thierry, the author of the "History of the Norman Conquest," affords an admirable contrast to that of Constant. His entire life presented a striking example of perseverance, diligence, self-culture, and untiring devotion to knowledge. In the pursuit he lost his eyesight, lost his health, but never lost his love of truth. When so feeble that he was carried from room to room, like a helpless infant, in the arms of a nurse, his brave spirit never failed him; and blind and helpless though he was, he concluded his literary career in the following noble words: "If, as I think, the interest of science is counted in the number of great national interests, I have given my country all that the soldier, mutilated on the field of battle, gives her. Whatever may be the fate of my labors, this example, I hope, will not be lost. I would wish it to serve to combat the species of moral weakness which is *the disease* of our present generation; to bring back into the straight road of life some of those enervated souls that complain of wanting faith, that know not what to do, and seek everywhere, without finding it, an object of worship and admiration. Why say, with so much bitterness, that in the world, constituted as it is, there is no air for all lungs—no employment for all minds? Is not calm and serious study there? and is not that a refuge, a hope, a field within the reach of all of us? With it, evil days are passed over without their weight being felt. Every one can make his own destiny—every one employ his life nobly. This is what I have done, and would do again if I had to recommence my career; I would choose that which has brought me where I am. Blind, and suffering without hope, and almost without intermission, I may give this testimony, which from me will not appear suspicious. There *is* something in the world better than sensual enjoyments, better than fortune, better than health itself—it is devotion to knowledge."

Coleridge in many respects resembled Constant. He possessed equally brilliant powers, but was similarly infirm of purpose. With all his great intellectual gifts, he wanted the gift of industry, and was averse to continuous labor. He wanted also the sense of independence, and thought it no degradation to leave his wife and children to be maintained by the brainwork of the noble Southey, while he himself retired to Highgate Grove to discourse upon lofty topics to his disciples, looking down contemptuously upon the honest work going forward

beneath him amid the din and smoke of London. With remunerative employment at his command, he stooped to accept the charity of friends; and, notwithstanding his lofty ideas of philosophy, he condescended to humiliations from which many a day laborer would have shrunk.

How different in spirit was Southey! laboring not merely at work of his own choice, and at task work often tedious and distasteful, but also unremittingly and with the utmost eagerness seeking and storing knowledge purely for the love of it. Every day, every hour had its allotted employment: engagements to publishers requiring punctual fulfilment; the current expenses of a large household duly to provide for. Southey had no crop growing while his pen was idle. "My ways," he used to say, "are as broad as the king's highroad, and my means lie in an inkstand."

THE OBJECT OF KNOWLEDGE.

IT IS not how much a man may know that is of importance, but the end and purpose for which he knows it. The object of knowledge should be to mature wisdom and improve character, to render us better, happier, and more useful—more benevolent, more energetic, and more efficient in the pursuit of every high purpose in life. When people once fall into the habit of admiring and encouraging ability as such, without reference to moral character, they are on the highway to all sorts of degradation. We must ourselves *be* and *do*, and do not rest satisfied merely with reading and meditating over what other men have been and done. Our best light must be made life, and our best thought action. At least we ought to be able to say, as Richter did, "I have made as much out of myself as could be made of the stuff, and no man should require more."

FROM THE PEOPLE'S RANKS.

THE new President of France is a son of the people. A farmer's son the French nation has just made their chief executive. What the American people did when they raised Lincoln to the Presidency of the United States, the French have now done in conferring the chief power of the nation upon Loubet. In this choice of a humble farmer's son for the highest dignity they could confer, the people have spoken the voice of that France whose bone and sinew are made up of the mass of plain people—a people who have made France great, just as the plain farmers of America have placed the greatness of this mighty republic upon its strong foundations.

Emile Loubet exhibits today, it is true, in his awkward manner, the traits of his early training, but displays, likewise, in an unmistakable manner, other sterling characteristics of the common people that any nation must admire—honesty and industry.

Lincoln was born poor, and throughout his life remained awkward—yet no man has ever rendered greater services to his country, and no man is so deeply and irremovably enshrined in the hearts of his countrymen.

Loubet's election is a sign full of promise for republican France. The new President was born in 1838 on a little farm at Marsanne, about two miles from Montelimar. It is a typical farm of the south of France. The President's mother—eighty-six years old—still lives, and manages the farm. She has never been in Paris, nor has her son's advancement in any way altered her. She wears the garb of the peasant, as her people have done before her—the homespun gown, gingham frock, and white cap with its fluted edges. She is a plain, sensible, clear-headed, peasant mother, proud of her son, but sorry to be separated from him.

In 1867, Loubet married Marie Denis, an ironmonger's daughter. Her father was a tramp, who came to Picardy and found employment in a nailsmith's shop at Montelimar. When he died he left a prosperous business to a son, who now operates it, and a fortune of 300,000 francs to his family. The president's wife was brought up in a simple way, and well trained in household duties. She dresses well, but makes no attempt to follow the fashions, and is, at all times, courteous and motherly.

In 1870, Loubet became mayor of Montelimar, and in 1876 was elected to the Chamber of Deputies. He has since filled, with credit and distinction, the offices of cabinet minister and president of the senate. He has now entered on his duties as chief magistrate of the nation, with every promise of success, with the confidence of the vast majority of his fellow countrymen, and the very best wishes of all foreign nations.

His success is due to his inflexible honesty of purpose and to the irreproachable character of his private life. His elevation to the presidency shows that no man, no matter how humble his origin, that devotes himself with singleness of purpose to the interests of his home and his country, can fail to receive recognition.

ELMER E. MILLER.

A SUCCESSFUL MECHANICAL ENGINEER.

THE subject of this sketch was born near his present home in Canton, O. His early education was received in the common schools, but he afterwards studied philosophy and developed a taste for mechanical work which he has always cultivated assiduously.

At the age of eighteen he was foreman in a sawmill, and two years later had charge of the steam plant of Miller & Co.'s planing mills. While still a young man he was employed as erecting engineer and machinist by C. Aultman & Co., and in 1889 accepted the position of chief engineer for the Gilliam Manufacturing Company, with whom he still continues.

ELMER E. MILLER.

In his position as mechanical engineer for the above firm, Mr. Miller has invented and constructed numerous machines and appliances which have greatly reduced the cost of manufacture in their special lines, as these machines now perform, automatically, many operations, formerly done entirely by hand. Mr. Miller's work in this line has done much to build up the establishment in which he is employed.

He has tested, indicated, and adjusted some of the most important steam plants in the West. During the last few years, has been doing professional work as consulting engineer, in addition to his duties as mechanical engineer of the Gilliam Manufacturing Company. He has recently installed for this company a model steam plant, equipped with all the latest and best steam specialties.

Mr. Miller is a thoroughly competent engineer of large and varied experience. By his industry he has acquired an interest in the Gilliam Manufacturing Company. He is married and has a beautiful home and an interesting family. He has reason to be proud of his library and laboratory, as they are among the best in the country.

He has served as Corresponding Engineer for Buckeye Council A. O. of S. E. for years, and Grand Corresponding Secretary for the State of Ohio, A. O. of S. E., also Corresponding and Recording Secretary of the Canton-Massillon Engineers' Association.

Like other successful men, Mr. Miller has steadily pursued the line of work for which he felt himself best adapted; seizing every opportunity to increase his knowledge and make his services of greater value. He is one of the many successful students of The International Correspondence Schools, and has this to say regarding his experience with them:

"There is certainly no better opportunity in the life of any young and ambitious man than a Scholarship in The International Correspondence Schools. A Complete Mechanical Scholarship cost me $40 in cash, and many hours of study in the morning and evening. The reward is equal to more than $10,000 invested in any bank in this country, as the increase in salary more than pays the interest on such an investment, and the capital, Education, will not fail with the bank but endure through life, and will always add new pleasures and more capital.

"The Schools have been a great help to me as instructor in engineering in Canton No. 45, National Association of Steam Engineers. I shall always give my warmest words of praise for the institution which has helped to make my life a success: The International Correspondence Schools."

INORDINATE AMBITION.

NORDHOFF counsels us in these striking terms: "Teach yourself to despise ambition; it is one of the meanest of passions." There are two ambitions: the honest, and the inordinate, which the line just cited justly condemns. Against the latter, we must guard ourselves.

Rapidly acquired wealth, or reputation, is more difficult to keep than to acquire. Men become slaves for life to reputation that they are not able to maintain, to wealth that they are not strong enough to handle. Remember that all solid growths are slow. Time is an element that must enter into all real education, sound character, and enduring reputation. Time is requisite for the execution of all comprehensive plans of action. "Time and I," said Mazarin, "against any other two."

Take care to profit by your own experience—especially by your blunders and mistakes. These are the most expensive teachers, but the best of all. Still better to learn wisdom from the failure of other men. The broader the range of digested experience, the sounder will be your judgment. The experience of the past is history; that of the present, observation. Both are requisite to understand either. Classified, they become science. Science joined with sound judgment, force, and steadiness of will, we call administrative power—the power to bring things to pass—and it is the highest, the rarest, and most valuable form of human capacity. Compared with it, mere genius is insignificant. Without it, nothing great or good is ever done. Those who have it are the great controlling and constructive minds of the world.

Your powers may not be great, your sphere in life may be narrow—this is the lot of all but a few—but all may attain strength of character, which will endure the tests of time. Seek to exercise your powers up to the limit of your faculties; and, if he is a benefactor of his race who "makes two blades of grass grow where but one grew before," you may hope in some degree to make the world better and happier.

MINER BOY TO MILLIONAIRE.

THE marriage of Miss Virginia Fair to W. K. Vanderbilt, Jr., adds another brilliant chapter to the romance of the bonanza miner, whom every old-timer on the Pacific slope knew as Jim Fair—of the poor tattered Irish boy of Calaveras County, whose life ranged from the lowest state of poverty to the most extraordinary wealth, whose children are now allied to the most powerful family in American finance, and to the proudest name in the nobility of Britain.

The grizzled miners of the Pacific coast delight in telling of the days when Jim Fair worked for wages beside the boys in the mines, and dined on bacon and beans. Miss Virginia Fair the old fellows remember as a baby in the camp at Virginia City, and her marriage has afforded such a flood of memories as nothing else in many a day.

James G. Fair was born in Ireland, in December, 1831. The family came, in 1843, to America, settling in central Illinois, where, while a mere lad, Jim Fair became a well-known farm worker. He ran away in 1847, walking to Chicago, and thence to New York, where he arrived in 1848. The news of the gold discoveries in California reached the Atlantic coast in the fall of 1848. Young Fair caught the fever, and getting a passage on a Panama vessel, set out for California, reaching San Francisco in 1850.

For fifteen years Fair worked in the gold mines with little success. In 1865, however, he struck a good ledge in Nevada County. His hunger and heartaches were forgotten when he opened the Hopewell Mine, his interest in which he sold for $9,000, with which sum he felt rich. In the same year he married Miss Rooney, of Calaveras County, and with her proceeded to Virginia City, then a mining camp of about 3,000 men and 400 women. Here he began work as a boss of laborers, but was, in a month, promoted. Just as he had attained the age of 37 he was superintendent of the Ophir mine. John W. Mackay, now president of the Postal Telegraph Company, and worth $30,000,000, worked, at the same time, as assistant superintendent in the California mine. The salaries of the two men were, at this time, about $2,500 a year each. Mackay and Fair came from the same part of Ireland, and had been fast friends in California. They had two friends in San Francisco, James C. Flood and William O'Brien.

In 1869, the mining world began to hear of Mackay, Fair, Flood, and O'Brien, and their operations in the mines, which they had combined into the California Consolidated Virginia Mining Company. In 1872 the California Consolidated was the most valuable mine property in America. In 1872–73, these four men made over $3,000,000 each. But the most wonderful discovery was yet to be made. In February, 1874, the

miners found a ledge of quartz, gold and silver, that has never been equaled. Virginia City went wild over the discovery, and California and San Francisco could scarcely credit the reports of the unparalleled value of the ore. The number of shares in the Consolidated Virginia was increased over one hundred per cent. and went from $48 a share to $450 in five days.

Between 1870 and 1876 the combined wealth of Fair and Mackay leaped from about $75,000 to more than $65,000,000. The firm had probably about $115,000 in 1870, and was worth over $130,000,000 six years later. Up to 1874 Fair and Mackay might have been seen in their oily overalls and old clothes about their famous mines, and their success is to be attributed to a readiness of purpose and a firm determination, enabling them to bear with their trials, to endure poverty with all its humiliations, and to turn its very bitternesses into sources of advancement.

James G. Fair died in March, 1895, but John W. Mackay still lives in the enjoyment of the wealth in whose acquirement he spent so much energy and labor, and displayed such thought and commendable persistence in his earlier days.

WHEN EDUCATION REALLY BEGINS.

FOR many men, education really begins when they leave school. Pietro di Cortona, the painter, was thought so stupid in school that he was nicknamed "Ass's head"; and Tomaso Guidi was generally known as "Heavy Tom" (Massaccio Tomasaccio), though by diligence he afterwards raised himself to high eminence. Newton, when at school, stood at the bottom of the lowest form but one. The boy above Newton having kicked him, the dunce showed his pluck by challenging him to a fight, and beat him. Then he set to work with a will, and determined also to vanquish his antagonist as a scholar, which he did, rising to the top of his class. Many of our greatest divines have been anything but precocious. Isaac Barrow, when a boy at the Charterhouse School, was notorious chiefly for his strong temper, pugnacious habits, and proverbial idleness as a scholar; and he caused such grief to his parents that his father used to say that, if it pleased God to take from him any of his children, he hoped it might be Isaac, the least promising of them all. Adam Clarke, when a boy, was proclaimed by his father to be "a grievous dunce"—though he could roll large stones about. Dean Swift was "plucked" at Dublin University, and only obtained his recommendation to Oxford by special favor. The well known Dr. Chalmers and Dr. Cook were boys together at the parish school of St. Andrew's; and found so stupid and mischievous that the master, irritated beyond measure, dismissed them both as incorrigible.

The brilliant Sheridan showed so little capacity as a boy that he was presented to a tutor by his mother with the complimentary accompaniment that he was a hopeless dunce. Walter Scott was all but a dunce when a boy, always much readier for a "bicker" than apt at his lessons. At the Edinburgh University, Professor Dalzell pronounced upon him the sentence that "Dunce he was, and dunce he would remain." Chatterton was returned on his mother's hands as "a fool, of whom nothing could be made." Burns was a dull boy, good only at athletic exercises. Goldsmith spoke of himself as a plant that flowered late. Alfieri left college no wiser than he entered it, and did not begin the studies by which he distinguished himself until he had run half over Europe. Robert Clive was a dunce, if not a reprobate, when a youth; but always full of energy, even in badness. His family, glad to get rid of him, shipped him off to Madras; and he lived to lay the foundations of British power in India. Napoleon and Wellington were both dull boys, not distinguishing themselves in any way at school. Of the former the Duchess d'Abrantes says, "He had good health, but was in other respects like other boys."

John Howard, the philanthropist, was another illustrious dunce, learning next to nothing during the seven years that he was at school. Stephenson, as a youth, was distinguished chiefly for his skill at putting and wrestling, and attention to his work. The brilliant Sir Humphry Davy was no cleverer than other boys; his teacher, Dr. Cardew, once said of him, "While he was with me, I could not discern the faculties by which he was so much distinguished." Indeed, Davy himself in after life, considered it fortunate that he had been left to "enjoy so much idleness" at school. Watt was a dull scholar, notwithstanding the stories told about his precocity; but he was, what was better, patient and perseverant, and it was by such qualities, and by carefully cultivated inventiveness, that he was enabled to perfect his steam engine.

SELF-CONFIDENCE.

TOO much guidance and restraint hinder the formation of habits of self-help. They are like bladders tied under the arms of one that has not taught himself to swim. Want of confidence is perhaps a greater obstacle to improvement than is generally imagined. It has been said that half the failures in life arise from pulling in one's horse while he is leaping. Dr. Johnson was accustomed to attribute his success to confidence in his own powers. True modesty is quite compatible with a due estimate of one's own merits, and does not demand the denial of all merit. Though there are those who deceive themselves by putting a false figure before their ciphers, the want of confidence, the want of faith in oneself, and consequently the want of promptitude in action, is a defect of character that is found to stand very much in the way of individual progress; and the reason why so little is done is generally because so little is attempted—as the old saying has it, "Nothing ventured, nothing won."

STICK TO YOUR BUSINESS.

"THE most valuable rule in life," says Richard R. Donnelley, the "prince of printers," in Chicago, "is to stick to your first deliberately chosen business. Stick to it through thick and thin; stick to it in adversity as well as in prosperity. In many instances the great and successful enterprises of today were abandoned by former owners, disheartened by small returns, and tempted to other adventures by alluring and perhaps deceptive appearances. Stick—stick—stick—whether your line is typesetting, or pork-packing, or dealing in dry goods or any other kind of goods!"

Richard Robert Donnelley began life as a printer's boy. He was born in the prosperous city of Hamilton, Canada, November 15th, 1836; his parents had recently come from Ireland, his father being Irish, and his mother English. The Donnelleys of Armagh had for centuries been manufacturers of linen. His mother was Jane Eliot, and traced her lineage back to Sir John Eliot, one of the great men of Cromwell's time.

Widow Donnelley sent her boy to the Hamilton public schools. He and his mates determined to emigrate to Jamaica, and made a bank of a teapot, wherein to deposit their shillings for the voyage. Playing truant to see the circus put an end to the dream of Jamaica, and also to Donnelley's school life. He was apprenticed to the printers' trade, and duly initiated as office drudge. Soon he went into another office as a printer—at one dollar a week for wages—and boarded at home.

The boy began to read evenings. His new life stimulated his ambition. He contracted with his employer to work nights and mornings and attend school in the daytime. For two years he attended the high school, studying by day and working by night. He became a thorough printer, qualified to direct, as well as to labor at the case, and he looked about for broader opportunities. Going to Chicago, he became a partner of William Piggot; thence he went to New Orleans to take charge of the job department of the "Delta." The war shattered his fortunes, as it did those of many others, and he went back to Hamilton, and the job case.

Misfortune could not crush Donnelley, however, and a few years later he was back in Chicago, doing a large printing business. In 1870 he led in organizing the Lakeside Printing Company, with a capital of half a million dollars. The great Chicago fire destroyed their building, and he lost $60,000; but in three days he had leased a building at $5,000 a year, and started for New York for credit. Though he frankly declared his wealth was represented by zeros, he was confident he could soon put significant figures before the ciphers.

In 1874, the Lakeside Publishing Company became the compilers and publishers of the Chicago "City Directory." In 1880, the Chicago Directory Company assumed the work, under Mr. Donnelley's management, which, in 1886, passed to his son, Richard H. Donnelley. From a "printer's devil," in his native Hamilton, to the "prince of printers," in Chicago, he stuck to his business through thick and thin and prospered. Mr. Donnelley has continued to prosper, and certainly the lesson of his life is one to be studied and remembered by all ambitious of honorable success.

EDISON'S ADVICE.

"WHEN you set out to do anything, never let anything disturb you from doing that one thing. This power of putting the thought on one particular thing, and keeping it there for hours at a time, takes practice; and it takes a long time to get into the habit."

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

IN THE INTERNATIONAL CORRESPONDENCE SCHOOLS,

SCRANTON, PA.

DOUBLED HIS SALARY BY STUDY.

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POSITION AND PROMOTION SECURED.

I am very much pleased with my Course of study in The International Correspondence Schools. Since I enrolled I have changed my position several times, each position being much better than the preceding. It was due to the Schools that I was able to procure my present position as die maker for the Yale & Towne Lock Manufacturing Company, and also caused my promotion during my first year with them. The knowledge obtained through my Course of study, gives me more confidence to undertake new work and helps largely to carry it to a successful issue.—*Samuel E. Dauchy* (*M. E. 49*), *Stamford, Conn.*

WORTH TEN TIMES ITS COST.

I wish I could be the means of every man running a steam plant joining the Schools. The aims and method of instruction are well set forth in the Circular of Information; but the benefits to be derived are understated rather than otherwise. The instruction furnished cannot fail to be a great lever for the advancement of engineers in knowledge and position. The information I gained by completing the Stationary Engineers' Course of The International Correspondence Schools has been invaluable in my work as chief engineer of a large manufacturing plant. I would not take for my course ten times its cost.—*Julian M. Tarbell* (*S. E. 602*), *Milford, N. H.*

EDUCATION AND PRACTICE ENSURE PROMOTION.

It has been two years since I finished the Complete Coal Mining Course of The International Correspondence Schools. I cannot commend the system of instruction too highly, as the knowledge gained through the Course has been of great benefit to me. Before enrolling in the Schools, I was a miner, but through the efficient method of instruction, I have been fitted to fill any position in and around a coal mine. Shortly after beginning to study, I was appointed foreman in one of The Union Pacific Coal Company's mines, and from foreman have been promoted to superintendent, which position I have filled ever since. Every coal miner should fit himself to assume the management of mines by taking this Course. —*Joseph Watson (C. M. 958), Baldwin, Col.*

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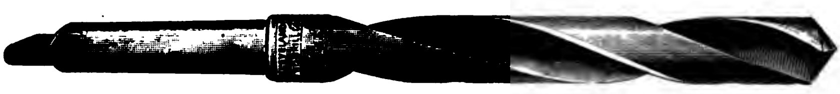

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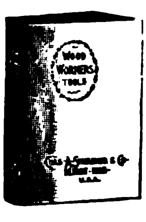

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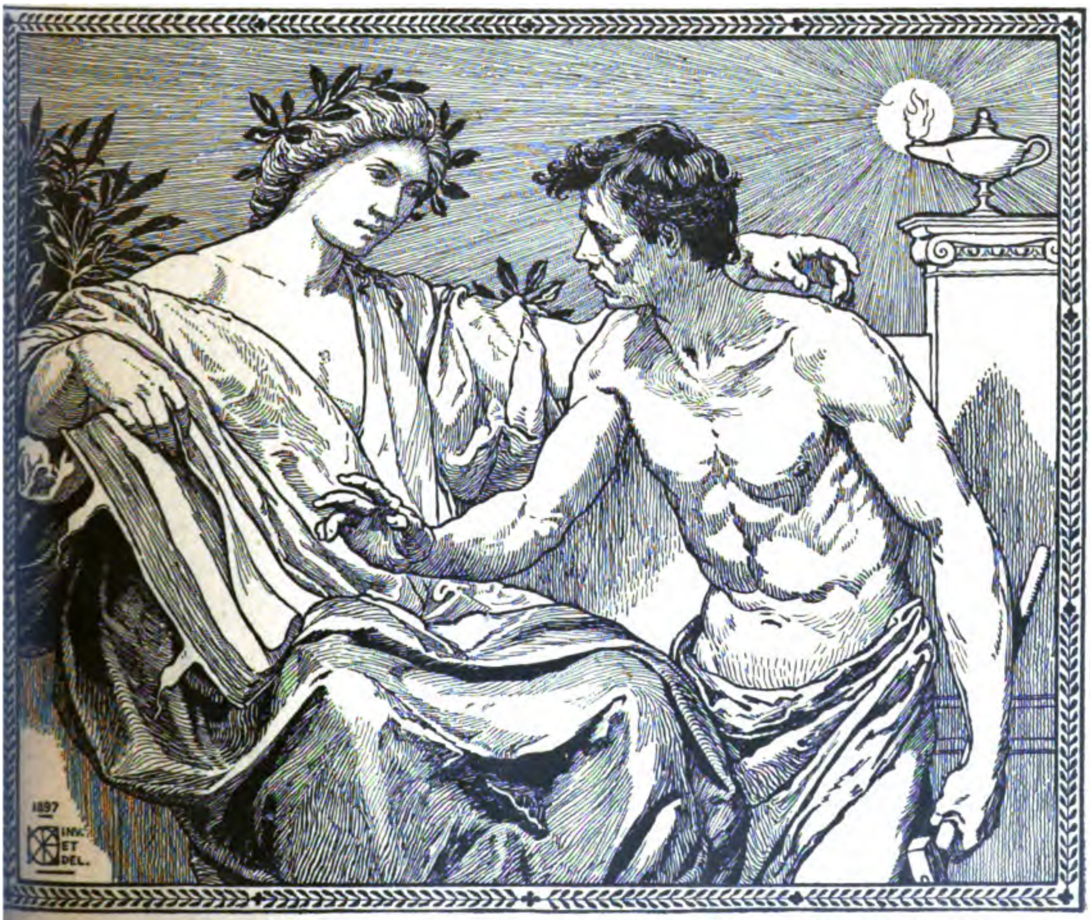

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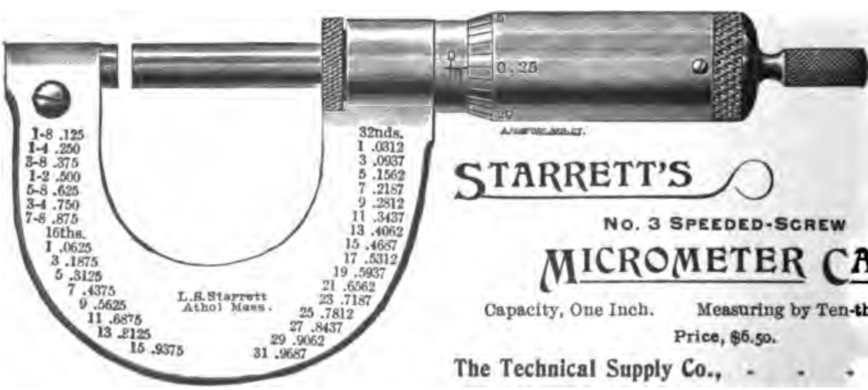

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Vol. IV. JUNE, 1899. No. 5.

THE TESTING OF STEEL.

(*Continued from the May, 1899, Number.*)

C. P. Turner.

THE STRESS-STRAIN DIAGRAM—SIGNIFICANCE OF THE RESULTS OBSERVED—VALUE OF THE COLD-BENDING TEST—EXAMPLES OF BROKEN AND BENT TEST SPECIMENS.

AFTER a specimen has been broken as described, and the broken pieces are placed with the fractured ends together, it is found that the marks made on the original bar are farther apart than before the test, showing that the steel has stretched before breaking. With very hard steel the amount of stretch is comparatively small, although there is always a measurable change in the length of even the hardest and most brittle steel. The softest steels stretch a great deal; the length generally used as a standard from which the stretch is calculated is 8 inches, and with the best grades of soft boiler plate or rivet steel an elongation of 2 inches, or 25 per cent. of the original length of 8 inches, is common, while more than 30 per cent. is sometimes obtained.

The relation between the pull, or *stress*, on the specimen and the corresponding change in length, which engineers now generally call *strain*, or *deformation*, is best shown by means of what is called a *stress-strain diagram*. Fig. 4 is such a diagram for a specimen of soft machinery steel. On this diagram the vertical distance from the horizontal line $o\,x$ of any point on the irregular line $o\,a\,b\,c\,d$ represents the stress, in pounds per square inch of sectional area, on the specimen, while the corresponding strain is represented by the horizontal distance of the same point from the vertical line $o\,y$. Each of the small spaces above the line $o\,x$ represents a stress of 1,000 pounds per square inch, while each similar space from the line $o\,y$ towards the left represents an elongation of the specimen of 0.01 inch, the original length in this case being 6 inches.

An inspection of the diagram shows that the elongation, when the stress has reached 40,000 pounds per square inch, is less than $\frac{1}{100}$ inch, and that up to this point the elongation increased in almost exact proportion to the increase in the load. Above the point a, corresponding to the stress of 40,000 pounds per square inch, the elongation increased more rapidly than the increase in the load, as is indicated by the curve from a to b. At b, when the stress has reached an intensity of about 43,300 pounds per square inch and the specimen has stretched about $\frac{1}{50}$ inch, there is a sudden change; the specimen stretches rapidly with almost no increase in the stress until the point c is passed, after which the load increases slowly again until the maximum, about 63,000 pounds per square inch, with a total elongation of 1.96 inches, or nearly 33 per cent. of the original length of 6 inches, is reached. In order to show the diagram on as large a scale as possible, the part beyond the 1.10-inch mark, which represents that part of the test during which the area of the specimen decreased before the break occurred, is omitted.

We will now consider the significance of the different features of the test, as shown by the diagram. From o to a we have seen that the strain is almost exactly proportional to the stress; that is, between these points the increase in the length of the specimen for each increase in the load of, say, 1,000

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pounds, is always nearly the same. Further, if a load less than the 40,000 pounds had been applied and then removed, it would have been found that the specimen returned to its original length; such a load would have produced no perceptible set, or permanent change in the length of the specimen, a condition which we express by saying that, within certain limits, the steel is perfectly elastic. The limiting stress below which there is no apparent permanent change in the length of our specimen, is called the *elastic limit;* theoretically, the material will safely carry any load within this limit. If the elastic limit is not exceeded, the material, after a load is removed, will return to its original form no matter how often such a load is applied and removed.

In consideration of the constant proportion which it is assumed exists between the stress and strain, the very expressive term, *limit of proportionality*, has been applied to the limit below which each increase of a certain amount in the load produces the same change in the length of the specimen. Although this limit, which for steel generally agrees very nearly with the elastic limit, is seldom considered by American engineers and writers of textbooks on the mechanics of materials, a factor that is much used in calculations pertaining to the deflection of beams and springs is based on the theory of the proportionality of stresses and strains; this factor, called the *coefficient*, or *modulus, of elasticity*, is the result obtained by dividing the stress on each unit of area of the section of a specimen by the resultant strain in each unit of its length. The English unit of stress generally employed for this purpose is the pound per square inch; using this unit, the coefficient of elasticity is the quotient obtained by dividing the product of the original length on which the elongation is measured and the total stress in pounds by the sectional area of the specimen in square inches multiplied by the total elongation in inches. The coefficient of elasticity may also be defined as the load in pounds that would stretch a specimen having a sectional area of one square inch to twice its original length, assuming the limit of proportionality to be sufficiently high to permit of this deformation under a constant ratio of stress to strain.

It is interesting to note that the coefficient of elasticity for all grades of steel is practically the same, about 29,000,000. The very delicate measurements involved in its determination leave the exact value somewhat in doubt, different observers having obtained values differing considerably from the coefficient here given.

We have seen that, within the elastic limit, as shown by the diagram, the total elongation of the 6-inch specimen is less than $\frac{1}{100}$ inch, and that this change in length requires the application of a stress of 40,000 pounds per square inch. The diagram also shows that, for the first increase of 3,000 pounds in the intensity of the stress beyond the elastic limit, the rate of elongation increases quite slowly, the total elongation, under a stress of 43,000 pounds, being less than $\frac{1}{50}$ inch. These small changes in length can be accurately measured only by the use of measuring devices of considerable delicacy, and much care must be exercised in order to determine the stress under which the rate of elongation begins to change. A number of very ingenious instruments have been devised, which, used in connection with the testing machines shown in Figs. 1 and 2, automatically trace a diagram similar to Fig. 4. These autographic devices, while very valuable for certain classes of testing, are rather delicate, and require considerable care and skill in their use; in order to produce reliable diagrams, they must be carefully attached to the specimen and accurately adjusted, and this takes more time than is generally available when a large number of tests must be made.

Our diagram shows that from *o* to *a* the line, even when its scale is multiplied five times, does not vary from a straight line by an amount that can be detected; however, by measuring the changes in the length of specimen with micrometer calipers measuring to $\frac{1}{10000}$ inch, it is found that the point where the line begins to curve is considerably below the point where such curvature is perceptible on the diagram; in other words, the true elastic limit is not at the point indicated by *a*, but at some point considerably below it. It is, in fact, altogether probable that, if we were able to make measurements sufficiently small, it would be found that steel is not perfectly elastic under even the least stress, and that any load, however small, produces some permanent set. For all practical purposes, however, we are justified in saying that there is a limit within which the recovery of its original form is complete, no matter how often the stress is repeated.

Various arbitrary rules have been proposed for locating the true elastic limit on a diagram similar to that shown in Fig. 4;

these methods, however, serve merely to locate a point on the curve which establishes, with a moderate degree of uniformity, a stress that bears a certain relation to the elastic properties of the material, but they do not definitely locate the true elastic limit, and, in the opinion of the writer, they are of comparatively little practical value in determining the properties of the specimen and its value as a material for constructive purposes.

There is, however, one feature of our diagram which marks a perfectly definite stage in the effect of the stress on the specimen, and one that is readily determined in ordinary testing, without the use of delicate instruments or much loss of time. From *b* to *c* the diagram shows that in the length specimen during the process of forging or rolling suddenly begins to loosen and fall off.

As previously explained, the point at which the specimen suddenly elongates, without an increase in the stress, is scientifically known as the *yield point*, while in practical commercial testing it is commonly called the *elastic limit*. In much the greater number of reports of tests on specimens that are sent out from the rolling mills, the value quoted as the elastic limit is really the yield point as determined by the simple methods described above. Although this point is not scientifically as correct a gauge of the properties of the material as the theoretically true elastic limit, it is, on account of the ease and certainty with which it is determined, practically a more reliable guide to the steel maker

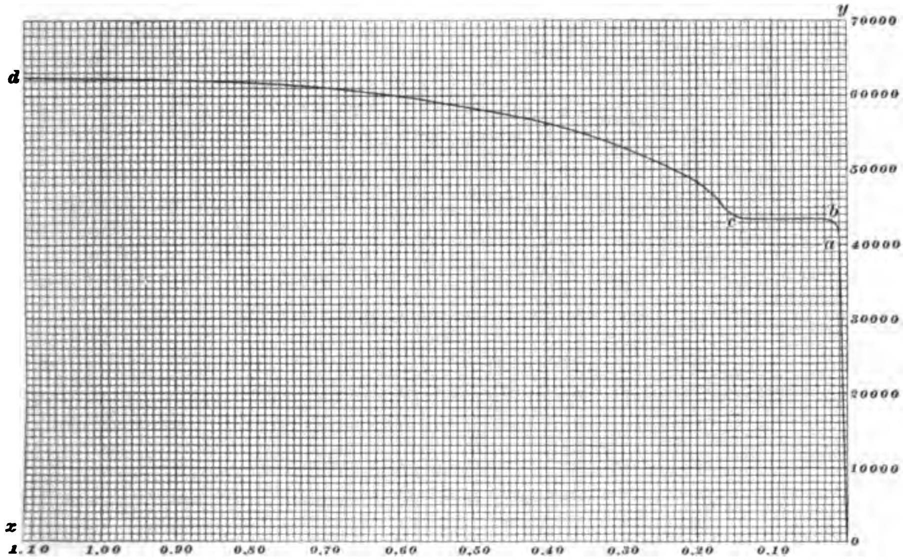


FIG. 4.

of 6 inches the specimen elongated about .12 inch, or nearly $\frac{1}{8}$ inch, with very little change in the stress. A little practice enables the operator to detect this period in the test without the use of any special instruments, particularly with all but the hardest grades of steel. As the stress is applied to the specimen, it is found that up to this point the poise must be steadily moved out on the beam of the weighing scale, but, when this point is reached, the beam remains stationary, with no change of the poise during a very perceptible lengthening of the specimen under the action of the stress. Also, if it has not been previously removed by machining, when this point in the test is reached, the scale formed on the

and steel user than the very uncertain theoretical point. Engineers do not intentionally design their structures to carry a stress as high as the true elastic limit, even though such a stress is theoretically safe; the almost universal practice is to determine the grade of the steel by the simple commercial tests here described, and then allow for a stress which practice has shown to be thoroughly safe for the given conditions and the grade of steel used.

The next feature of the diagram, Fig. 4, that merits our attention is the maximum stress borne by the specimen before it finally begins to reduce in section or breaks. This is commonly called the ultimate, or breaking, strength of the material, although, owing

to the reduced area, the stress under which the specimen finally breaks is generally much less than the maximum, and *tenacity* a more satisfactory term, has sometimes been used to designate this important property of the material.

In order to keep the scale of our diagram as large as possible, that part beyond the point showing the maximum stress on the

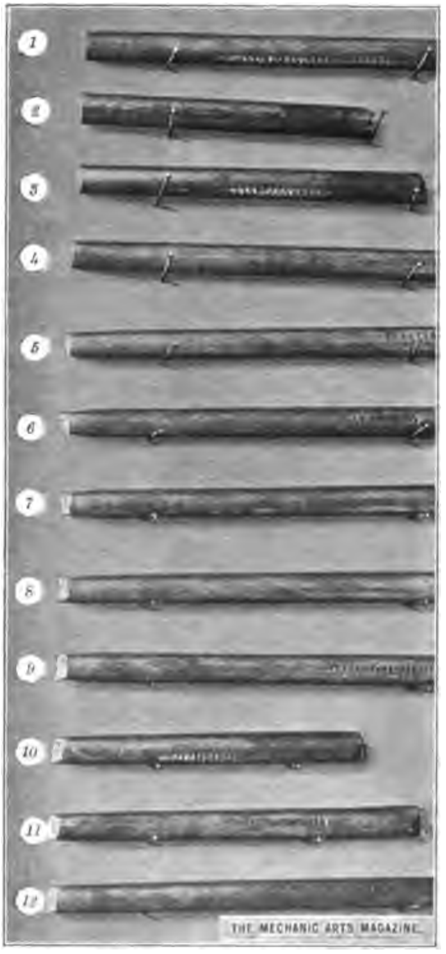


FIG. 5.

specimen was omitted; the total elongation of the specimen was 1.96 inches in the original length of 6 inches, or 32 per cent. of the original length.

The amount of elongation before fracture is a valuable index of the quality and properties of the material. The softer the steel, the greater, in general, will be its elongation. A high elongation is an indication of a metal of good quality, one that is malleable and ductile and will stand considerable deformation while cold, without being seriously injured—properties that are especially desirable in steel or iron to be used for boiler plates and rivets.

A very interesting feature of a tensile test is the reduction in area of the specimen at the point where it finally breaks; with the softer grades of steel the area of the fractured section is often less than half the area of the original bar, and the reduction sometimes exceeds 60 per cent. of the original area.

At one time a high percentage of reduction was thought to be an indication of a high quality of material, and this element is still given considerable weight in most commercial tests and specifications, especially for those grades of steel in which ductility and toughness are especially desirable qualities. If accompanied by a good degree of elongation, a high percentage of reduction at the point of fracture is an indication that the material has the desirable qualities of combined ductility and malleability; by itself, however, it may be merely an indication of a lack of uniformity in the diameter of the specimen or of homogeneity of the material, which results in a rapid failure at the weak point. These considerations have led some engineers to look on a high percentage of reduction with considerable suspicion.

There is yet one other element of the tensile test of iron and steel that deserves our notice. The character of the fracture is generally noted by the operator, and often by the inspector, when making commercial tests; since, however, this is a feature that cannot be directly measured and readily compared with some fixed standard, it is not given a great deal of prominence in most tests and specifications, although to an experienced observer it is regarded as a most valuable indication of the character of the material.

An excellent method of testing the ability of steel or iron to withstand the effects of severe distortion when cold, either from the processes of manufacture or during subsequent use, is by cold bending. Many specifications for steel to be used for members of bridges or for boiler plate and rivets—uses in which the metal is subjected to severe stresses and distortion during such operations as punching, shearing, flanging, and riveting—call for cold-bending tests, in addition to the tests made by a testing machine. The bending test has the advantage of

requiring no expensive outfit for its application, thus making it available where the

FIG. 6.

more complete tests are impracticable; unfortunately, however, the methods to be

No. of Specimen.	Chemical Properties. Percentage of Carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.	Physical Properties. Elastic Limit. Lb. per Sq. In.	Ultimate Strength. Lb. per Sq. In.	Elongation. Per Cent. in 8 In.	Reduction in Area. Per Cent.	Character of Fracture.	Process of Manufacture.	Use for Which Steel Was Made.
1	.64	......	......	......	......	87,140	145,300	10.0	17.8	Fine crystalline.	B.	....
2	.71	......	......	......	.95	81,480	146,400	5.0	7.8	Fine crystalline.	O. H.	Fork steel.
3	.53	......	......	......	......	76,960	128,300	11.0	22.6	Fine crystalline, center granular.	B.	....
4	.42	.070	.099	.032	.90	74,020	121,550	12.5	22.6	Fine crystalline, center granular.	B.	Rails.
5	.12	......	......	......	......	43,000	62,480	28.0	55.6	Cup, silky.	B.	Wire.
6	.12	......	......	......	......	42,550	65,640	26.0	55.6	Cup, silky.	B.	I beams.
7	.10	......	......	......	......	39,380	59,520	27.0	57.3	½ Cup, silky.	B.	Soft wire.
8	.14	......	......	......	.76	48,900	70,400	25.0	46.2	½ Cup, silky, center granular.	B.	....
9	.44	......	.045	......	.48	52,060	88,280	20.0	38.1	½ Cup, silky, center granular.	O. H.	Crankpins
10	.32	......	......	......	......	62,020	95,740	18.0	40.2	½ Cup, silky, center granular.	B.	....
11	.20	......	......	......	......	52,060	76,760	22.0	42.3	½ Cup, silky, center granular.	B.	....
12	.42	......	.021	.030	.40	46,400	78,300	20.0	33.8	½ Cup, silky, center granular.	O. H.	Car axles.

employed and the significance of the results obtained have never been well enough standardized and classified to enable us to draw as correct inferences from such tests as the method seems capable of furnishing when properly developed. The "Manufacturer's Standard Specifications for Structural Steel" demand bending tests for the different grades of steel commonly used for structural purposes. The angle of the bend in each case is 180°, and the inner radius of the bend varies from 0 for steel having a tenacity of 62,000 pounds per square inch, or less, up to one-half of the thickness of the specimen when the tenacity does not exceed 70,000 pounds per square inch. The specimens must stand this test without fracture on the outside of the bent portion. Since, however, a quality of steel that is satisfactory in other respects will readily fulfil these conditions when carefully handled, bending tests made in accordance with these specifications appear to have little real value, and, until the methods of making such tests are properly standardized, the results obtained must be unsatisfactory.

Figs. 5 to 10 are from photographs of a representative collection of broken and bent test specimens, and the accompanying table gives such chemical and physical properties as are usually determined for the various grades of steel illustrated by the different views. These specimens, for which the writer is indebted to Mr. C. S. Price, general manager of The Cambria Steel Company, are good average samples of the material produced by the Bessemer and open-hearth processes of steel making. They illustrate very clearly the results obtained by such tests as have been

FIG. 7.

described, and will give the reader a very good idea of the great range of properties

that are covered by the different materials classed together under the very indefinite name of steel.

An inspection of the table shows at a glance that the principal factor in determining the strength and hardness of the material is the percentage of carbon in its composition. Important as this element is, it is interesting to note how small a proportion is actually present, and what a narrow range of percentages is included between the $\frac{1}{10}$ of 1 per cent. of carbon in No. 7, the softest and most ductile specimen, and the $\frac{71}{100}$ of 1 per cent. in the hard and comparatively brittle material of specimen No. 2. These limits are seldom exceeded in steel made by the Bessemer and open-hearth processes, although more than 1 per cent. of carbon is sometimes found in special grades of open-hearth spring steel.

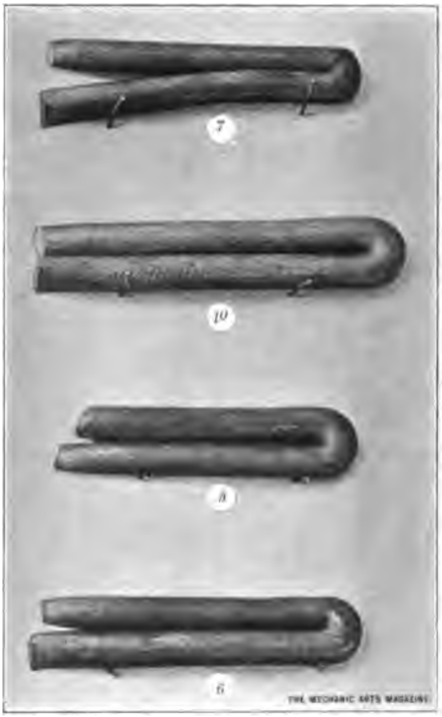


FIG. 8.

Of the other elements, phosphorus and manganese have a hardening effect, as will be seen by a comparison of the physical properties of Nos. 4, 9, and 12. The percentage of carbon is practically the same in each of these specimens, and the differences in their strength and ductility may be attributed to the differences in their percentages of phosphorus and manganese. Phosphorus, while it adds to the strength and hardness of steel, is one of the most undesirable elements in its composition, since it makes the metal *cold short;* that is, it is brittle and unreliable when cold.

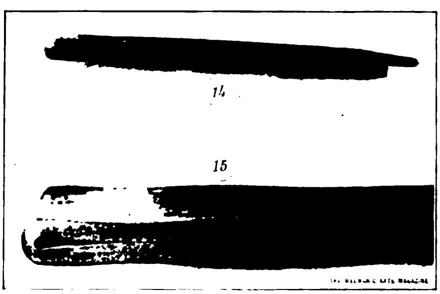


FIG. 9.

In its effect on the strength of steel, sulphur is not as marked as the other elements noted in the table, but it has the very undesirable effect of making the metal brittle when hot, and therefore difficult to work in the rolls and forge—a condition that is commonly expressed by the term *red shortness.*

The different degrees of ductility indicated by the columns in the table which give the percentages of elongation and reduction, are shown in a very marked manner by the appearance of the ends of the different specimens, as shown in Figs. 5 to 8. Figs. 5 and 7 show that the fractured ends of the harder steels, Nos. 1 to 4, have very little reduction from the original size of the bar, and that the fractured surfaces are comparatively flat, rough, and crystalline in appearance, and lie at nearly right angles to the length of the bar; this is especially true of the hard specimen, No. 2.

The different views of the softer specimens show very clearly the change in section that takes place when steel of this character is broken by a direct pull. They also show that the fractures, instead of being comparatively even and square with the bar, are very irregular. The fracture of such steel often takes a form which is commonly described as a *cup*, or *half cup*, one of the ends being either wholly or in part concave, as is shown in the enlarged end views in Fig. 6, while the other is correspondingly convex. In some cases, however, especially with flat bars, the fractured ends are nearly flat and smooth, but their surfaces, instead of being nearly at right angles to the length of the bar, as in the case of Nos. 1 to 4, form an angle of about 45° with it. Instead

of the rough, crystalline surface noted for the hard steels, the fracture of the soft grades has a surface which slightly resembles the glossy appearance of woven silk, thus giving the name "silky" commonly applied to this fracture. In many cases the broken ends of these bars of soft steel present a slightly fibrous appearance, almost like that of a bundle of the finest filaments of silk; in steel made by a process in which the metal is rolled or forged from ingots cast from a liquid mass there is, however, but little if any real fiber, such as exists in good wrought iron.

The centers of the broken bars of medium carbon steels generally show a dull and slightly granular structure, which gradually merges into the crystalline when the steel is comparatively high in carbon, or into the silky for softer grades. This condition is quite clearly shown in specimen No. 4 of Fig. 7 and the two specimens of soft steel in Fig. 6.

The results that may be obtained by bending specimens of good mild steel, cold, are very clearly shown in Figs. 8, 9, and 10. The number opposite each of these specimens corresponds with the numbers in the table and the preceding figures, with the exception of 13, 14, and 15, which are flat specimens, cut from soft bridge bars, probably rolled from steel of about the same grade as specimens Nos. 6 and 8. No. 13 was planed from a bar $\frac{13}{32}$ inch thick, and No. 14 from a bar $\frac{7}{32}$ inch thick; while No. 15 is a full-sized specimen from a $3'' \times \frac{3}{8}''$ bar.

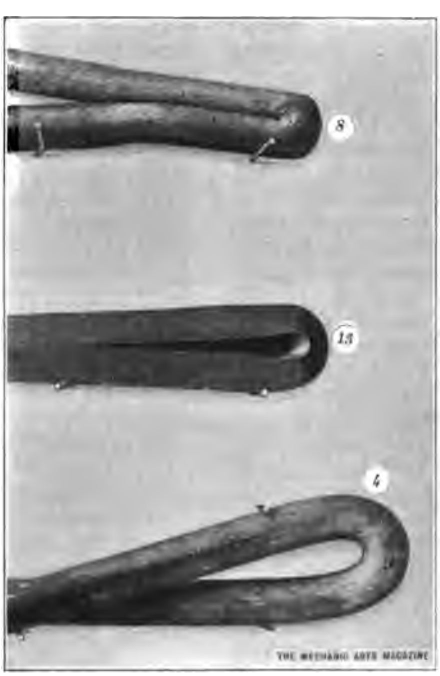


FIG. 10.

Specimens Nos. 7 and 8, Figs. 8 and 10, after being bent to an angle of 180°, were flattened under a heavy hammer until the thickness between the flattened faces is $1\frac{1}{8}$ inch in No. 7 and 1 inch in No. 8, the original diameter of the bars before bending being $\frac{3}{4}$ inch.

Specimen No. 4, Fig. 10, is particularly interesting as an example of the results that may be obtained with rail steel of a high tensile strength. This $\frac{3}{4}$-inch specimen was bent through an angle of more than 180°, as shown, to an inner radius of less than $\frac{3}{8}$ inch without cracking it on the outer surface of the bend; this is a test that is seldom demanded for steel having a tensile strength of more than 75,000 pounds per square inch.

It should be remembered that the tests here described and illustrated show the character of the steel when prepared according to a certain fixed standard; the operations of hardening, tempering, and annealing, or of working at a temperature much above or below the standard, will affect the character of the material as shown by these tests to a very remarkable degree. This is especially true of the high carbon steels; and it is on the proper control of these operations, nearly as much as on the original nature of the metal, that successful results are obtained in the manufacture of tools and springs. As the percentage of carbon decreases, the effects of variations in heating and sudden cooling become less, until, with the very softest grades, it is nearly impossible to produce a perceptible degree of hardening when the metal is suddenly quenched from a bright-red heat.

The tests of finished steel are made in practically the same manner as those just described, the principal difference being in the manner of preparing the specimens. For tests of bars and plates, the specimens are generally prepared by planing or milling from the finished material a rectangular piece about 20 inches long, having two sides covered with what is called the skin or scale formed in rolling; small bars are tested full size.

Tests of large or irregular pieces are made on carefully turned specimens, cut either from the full-sized piece or from a "coupon"—an extension forged on the main piece for this purpose.

BRIAR TEETH AND RAZOR EDGES.

By Inspector.

A Prevailing Workshop Practice That Leads to All Sorts of Trouble, and the Remedy Employed by a Leading Manufacturing Concern.

UNDER the above heading a few remarks will be made that may prove both interesting and instructive to those who are engaged in either making or using machinery.

In drilling a hole through a piece of metal, we get, as shown exaggerated in Fig. 1, a razor-like edge on the entering side, and a feather edge, or burr, of briar-like teeth on the other. Similar edges are produced in many other ways—in the lathe, on the planer, in the milling machine, in short, by almost every finishing tool—and there is perhaps no workshop practice so common and withal so bad as leaving these edges keen and sharp. For instance, on drilled work it is the practice to run the drill through the piece, and to call the hole thus made "finished," without removing either the razor edge or the briar teeth. The same practice prevails where holes are bored in pulleys, wheels, boxes, bushings, etc.; even where a hub is faced off before or after boring, it is the almost universal practice to allow the razor-like edge to remain; likewise, after reaming a drilled hole to exact size and roundness, the keen edge is left and the work passed as finished. And it is the same with the ends of turned shafting, and the edges of milled or planed work.

Fig. 1.

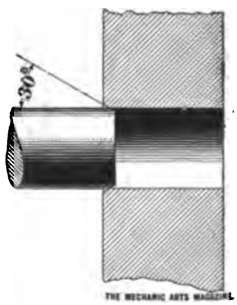
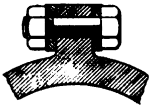


Fig. 2.

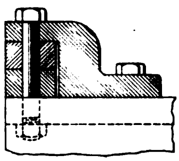
Now, all this is very bad. How many machinists that will not recall cases where, being unable to see to their satisfaction whether or not the holes in two or more parts to be bolted together were in correct alinement, they have thrust their finger in, to *feel* for what they could not *see*, only to be rewarded with a stab from a "briar tooth," or a gash cut half way around the finger from a "razor edge," edges previously passed as "finished"? Again, what engineer or machinist that has not found out by experience that, when making a final examination for rough places or bruises made in handling, or caused by the use of heavy tools in connection with the work, he runs the risk, when passing his hand around the end of a shaft, of having a crescent cut into his palm by the "razor edge" left when finishing in the lathe?

Did it ever occur to the reader that what happens to his finger under the above conditions may happen in a similar manner to a close-fitting bolt or pin? And the nature of the damage in the latter case is the more alarming, for the *hole* suffers as well as the bolt. Take the case of a shaft with keen end-edge, upon which bored work is being forced, the edge of the bored hole being also keen and sharp: at the moment of entering, the shaft bumps against the edge of the hole, part of the keen edge of the shaft being turned outward upon the shaft, and part of the edge of the hole being turned into the bore. The damage that this will cause depends on the weight of the parts and the force used to put them together, but briar teeth will thus be formed that will be a menace to all succeeding operations, and will in any case scratch both the shaft and the bore; if the shaft is a tight, forcing fit, it will probably "end up" and have to be forced out again, leaving the work in a mutilated and damaged condition; then the razor edges and the briar teeth will have to be removed and the work of assembling started over again. No amount of lubricating, either with oil or white lead, to reduce friction, and no other artificial means of smoothing the way, can take the place of properly preparing the work at the outset; this direct preparation should be done while the work is in the machine, and no work should be called finished until it has been done. In this connection we may cite the practice of a well-known and prosperous manufacturing concern—makers of bridge-work, and of hoisting and conveying

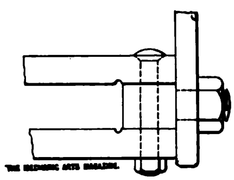
machinery, in which many such detail constructions as are illustrated throughout this article occur: To insure against the "unknown quantity" involved when sharp corners are left on, they have the ends of all shafts, tight-fitting bolts, and pins of every description turned off slightly



SLIDING SLEEVE.



PARTS SECURED BY BOLT.



GUIDE BARS AND CONNECTION.

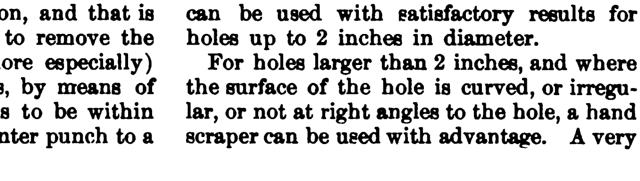
at an angle of 30°, and the edges of all bored holes chamfered off in the same manner, as indicated in Fig. 2. With planed work, the same general principle is applied, but the angle of the chamfering is made 45°. This chamfering is a matter of business throughout the shops, and is done in as direct a manner as possible, and in the course of the other work—not as an after consideration, and not as if it applied in special cases only, but always and invariably. Likewise, it is understood throughout the shops that on all drilled work the burrs and sharp corners must be removed by the rise of a fluted tool of 60° angle, the tool used being made of such proportions as to take in a generous range of work.

When holes have been finished in this manner, and tight-fitting bolts, pins, and shafts have had their sharp corners chamfered off as described, all tendency to jam or cut is at once removed; and the beveled edges obtained, though of but slight proportions, act to pilot, or direct, the course of the bolt, pin, or whatever it may be; thus, when a pin is to be passed through two or more parts, the chamfer enables it to draw the parts into correct alinement, preventing trouble from what would otherwise be a source of serious mischief and damage. As will be readily believed, this system materially reduces the cost of manufacture.

There is one commonly prevailing practice that deserves complete condemnation, and that is the allowing of drill hands to remove the burred edges that occur (more especially) on soft-steel plates and bars, by means of any "weapon" that happens to be within convenient reach, from a center punch to a half-round file, from the head of a cold chisel to a hammer (any old thing is considered good enough on drilled work), with which to "stab," "pick," "slash," or "clout" the edge of a drilled hole into what he considers "good shape." Now, in every such case, irrespective of the kind of material being worked on, he will turn much of the offensive burr back *into* the hole, and while he may succeed in removing the larger part, he cannot avoid leaving the edge in a badly damaged condition—a condition that may be fruitful of serious and costly trouble later on.

It was not the writer's purpose at the outset to make any special mention of drilling tools as such; yet it may be entirely in order and of some service to point out that the amount and character of the burr on the under side of a drilled hole is very largely dependent on the condition of the drill itself. A dull drill always forces out a large burr, and in addition tends to bulge the work itself, while a keen drill, properly ground, will produce clean work, with small burrs and no bulging whatever.

There is more than one good way of removing a burr from drilled work, though the best is to employ the fluted tool already described. Where it is desired to perform the operation by hand—in cases, say, where only a small number of pieces are to be done at one time—the next best thing is to have a tool resembling a carpenter's brace, but specially adapted to firmly hold the shank of the fluted tool. It should be explained that the flutes in this tool should be irregular in depth and spacing, so as to avoid the chattering and consequent "chatter marks" that will otherwise be produced on most metals. If correctly made, the same tool

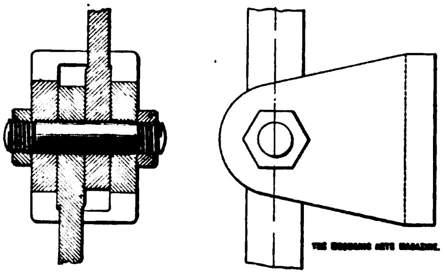


A BOLTED STRUCTURAL CONNECTION.

can be used with satisfactory results for holes up to 2 inches in diameter.

For holes larger than 2 inches, and where the surface of the hole is curved, or irregular, or not at right angles to the hole, a hand scraper can be used with advantage. A very

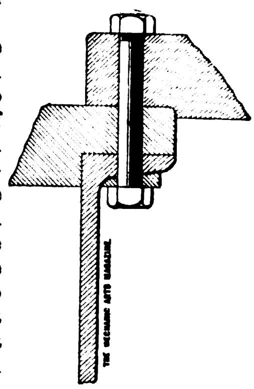
desirable double-edged scraper for this work can be made out of an old file, say 8 or 10 inches long, by grinding off the teeth until two perfectly clean-cutting edges are obtained. When once familiar with the use of a tool of this kind, the workman will find it an easy matter to remove the burred and the sharp edges from holes, and the resulting condition will be satisfactory in every way. The tool cannot be prepared



CHORD BARS AND CONNECTION.

too carefully, because it will last for a long time without being resharpened.

Not long ago, it became a matter of importance to the writer, in connection with a certain job, to obtain tight forcing fits with the lowest possible forcing pressure, as indicated by the hydraulic press. One day, a shaft 3 inches in diameter was being pushed into a hub 10 inches long, when the gauge indicated a pressure much higher than was admissible for the thickness of stock in the hub, showing that the fit was too tight. On removing the shaft it was found that the old story was being told over again: A small sharp burr on the edge of the hole had been turned in when the shaft was entering, had rolled and crawled in with the shaft, gathered in volume as it went along, and finally balled up into a wad, which, if pressure had been continued and increased, would have gradually grown until an infinite pressure would have been required to move it. Even as it was, when the shaft was forced out in the direction it had been entered, it carried along with it a large portion of the face of the hub, and consequently completely disfigured the work.



A BOLTED DETAIL.

Careful consideration of this subject will demonstrate that on all classes of machine work it pays to remove the "briar teeth" and "razor edges."

HOW TO READ.

Extracts from an Essay by the President of Lake Forest University.

THE successful reader is one who thinks more than he reads. The advantage of reading is in the obtaining of information or ideas which are then brooded over, as a hen broods over her eggs, and are made productive of new life and of new beauty. The saying that mankind may be divided into two classes, those who read and those who think, is suggestive. Reading may be simply the pouring of water into a sieve. The best readers are those who know how to find suggestions that stir the mind and cause it to make excursions in new realms of thought. Almost any worthy book that comes into our hands will bear more than one reading. Indeed, all great books must have more than one reading if they are to be appreciated.

Were I to state the prime requisite of successful reading, I would say that it is attention. Many persons read without being able to get a clear opinion at the conclusion of their reading as to the ideas that have been before them. I knew a young man, a student of the law, who was accustomed to put a mark in his book at the page he had reached in his reading. His roommate every now and then would place the book mark several pages back in the volume, and the young man never knew the difference. Attention sometimes necessitates very slow reading.

Every man has to learn for himself how to read. He must know why he wishes to read, and then he must know what he wishes to read. Then, in due time, if he reads to develop thought and to insure accurate expression, he will acquire habits of selection and of proportion that will make his reading a success to himself and a blessing to others.

IN THE WORKSHOP.

(*Continued from the May, 1899, Number.*)

H. Rolfe.

LONG VERSUS SHORT BOILER TUBES—IMPORTANT CONSIDERATIONS GOVERNING THE LENGTH. FIGURING ON DRAFT AREA.

IN CONNECTION with the subject of locomotive tubes, there are other directions than that mentioned in our last in which a good thing is often "overdone"—in that of length, for instance.

Of course, the length of a boiler tube is to a great extent fixed by the type and design of engine. Speaking generally, the length depends on the wheel base, which in turn depends on the type of engine, the size of drivers, and the nature of road (as to curves). Supposing an eight-wheeler is being laid down; we know beforehand what work the engine is to do, and the kind of fuel to be burned, and have decided on the steam pressure and the size of the cylinders and wheels. We therefore know what the grate area will have to be. If for bituminous coal, we can generally put the firebox in between the main and the rear axle, without getting too long a side rod; having settled on the wheel base for the drivers, we know pretty well where our truck will be with a view to good distribution of the weight. The determination of this locates our cylinders and, practically, our front tube sheet also; and, the back sheet being already located, our tube length follows.

Sometimes an extra inch or two of width is obtained by making the upper frame brace of slab form from the main to the rear driver. We think it preferable, on the whole, to lift the box up above the frames and so get yet another two or three inches; then, also, more latitude ensues as to tube length, as the box can be carried back somewhat and a longer tube used. But we cannot do much as regards *shortening* the tubes, being restrained by various considerations, such as allowing proper clearance for the eccentrics, and also for the springs—in some kinds of spring rigging.

For bituminous coal the box can be shortened and so a longer tube obtained without increasing the wheel base. With both eight- and ten-wheelers, the box, when it is above the frame, can be carried back over the rear axle and a longer tube used, without increasing the wheel base. In consolidation engines we naturally have long tubes, for the firebox has to be kept back of the third pair of coupled wheels, assuming them to be the main drivers. In eight-wheelers, when a large barrel occurs in conjunction with large drivers, the boiler has often to be set so high that a firebox of normal depth naturally takes a position above the frames. The designer should see to it that the tube is not too long for its diameter; when previously settling on the draft area he will have known approximately what the tube length would be, and have so chosen the diameter as to prevent undue sagging. Sometimes tubes are given a slight camber to overcome the tendency to droop.

In choosing the diameter, the two extremes are to be avoided. As pointed out last month, there are many evils that result from the tubes being too small; and if too large, heat will be wasted and the draft will be sluggish, but, on the other hand, the flame will remain alive further in the tube, and thus more perfect combustion will ensue, and more of the heat from the coal be given to the water.

As already stated, the tube length is largely fixed by other considerations, but designers have ere now gone out of their way to obtain a long or a short tube, according to their individual preference. In Europe we have seen six-wheeled engines with overhanging cylinders and fireboxes; that is, the whole box was behind the rear axle. This was done not only to keep the wheel base short (being rigid throughout), but also to admit of a longer barrel and therefore longer tubes. On the other hand, where the boiler has been set above the frames, it has sometimes been carried just about as far forward as clearances would permit, so as to cut down the tube length, the box being made larger to give the necessary heating surface. Where the box has been between the frames, and also when above them, the main drivers and truck have been brought closer together with the above aim in view. Often, too, the box has been set back bodily, to get a longer barrel while keeping the wheel base the same. Now, the first design (the six-wheeler) is not likely to be perpetuated, but the other practices

may be repeated, and we simply point out how, in each case, a thing may be carried to extremes. The tendency of a good many designers *is* to cut down the tube length, knowing that, area for area, it is of much less importance than the firebox sheets, but still the tubes are by no means cold bodies—in fact, from one-half to five-eighths of the steam making is done by them. So long as the gases escape from the front end of the tubes at a temperature of from 600 to 700° F., as is the case when an engine is working hard, there is good work for the tubes to do, the temperature of steam at 180 pounds pressure being only about half of the above. It is when you are going to use a high rate of combustion (which means a fierce draft and rapid flight of the hot gases to the stack) that you need a long tube so as to prolong the heat-absorbing process.

Before leaving this subject of tubes, we may caution the young designer against losing sight of the fact that the draft through the tubes is decreased by the ferrules in the back tube sheet, particularly when they are *inside* the tubes. The mistake has been made before now of simply taking the normal bore of the tube into account and forgetting that it is really the ferrules that govern the gross flue area; and, as it happens, the ferrules are put into the smallest end of the tube—an unfortunate coincidence. We say "smallest end of the tube" because the holes are usually made from $\frac{1}{16}$ to $\frac{1}{8}$ inch larger in the front tube sheet, to make it easier to draw the tubes when renewing or reending. So the ferrules should not be forgotten.

Now, the point may occur to many: Is all the thoughtlessness confined to designers? Are there not cases where the mechanic overdoes it sometimes? Well, yes, there are, and we will try to present a few instances next month in the form of a mild indictment against the shopman.

(*To be Continued.*)

TYCHO BRAHE.

George McC. Robson, M. A.

THE TYCHONIC SYSTEM OF THE UNIVERSE—THEORY IN CONFLICT WITH OBSERVATION—ANCIENT ASTRONOMICAL INSTRUMENTS—A MODERN HINDU RIVAL OF TYCHO BRAHE.

THE pages of this magazine frequently contain descriptions of the superb scientific instruments and wonderful machines devised and constructed in these latter days to assist the scientist in his investigations and the laborer in his work. The most abstruse researches of theoretical science, the greatest undertakings of practical engineering, and the simplest affairs of life are alike facilitated by an equipment of appliances, each of which requires for its construction the accumulated knowledge of ages, and the mechanical skill developed by the training of successive generations for centuries. The employment of these appliances is such a familiar experience that one almost forgets that they are not as much a part of his natural environment as is the atmosphere; and when the scientific and engineering triumphs of the last decade are reckoned up, due credit is not always given to the long line of faithful toilers who, in former decades, patiently and laboriously laid up the store of knowledge that makes these triumphs possible. When one rejoices over the progress of this progressive century, it is well to abstain from imitating the nobleman that boasts of the number of birds he has killed, and forgets to mention the assistance he received from the gamekeeper. At the close of a busy and successful day, when one feels that he has accomplished something to earn a night's repose, it is interesting to consider how much of the day's work he could have performed by his own unaided efforts, and how far he is indebted to external assistance: his breakfast hour is regulated by a watch constructed with marvelous mechanical skill, which he possesses not; he rides to his office in a car propelled by a mysterious power of which he, perhaps, knows little; his letters are written in indelible ink, on smooth white paper, with a fine steel pen, none of which were made by him; his messages pass under three thousand miles of stormy seas, over a cable which his brain did not plan, and which was not laid by the toil of his hand; his merchandise is borne to distant lands in a stately ship, though he did not devise the subtle conscience—called a compass—that directs her path, nor did his genius subjugate the monster whose throbbing mighty heart supplies her motive power;

if he is an engineer or an astronomer, he is continually using mathematical tables and formulas that the labor of his whole life would be insufficient to calculate independently, and he uses delicate instruments that he could not construct for himself. A distinguished writer has said that Kant was an intellectual Melchizedek—without father, without mother, without descent, having neither beginning of days nor end of life—which is a somewhat metaphorical way of saying that Kant was intellectually a self-made man and owed nothing to preceding philosophers. This may be true of the great philosopher, but it is absolutely certain that no such statement can ever be true of any worker in the domain of pure or applied science, or even in the most trivial affairs of life; whether we will or no, we are the heirs of the ages, and we can by no means escape from our inheritance.

TYCHO BRAHE.

Tycho Brahe is, in many respects, the most picturesque and interesting personage in the honor roll of great men that have amassed for us our precious heritage of skill and knowledge. The stock of knowledge that he inherited was very meager compared with the vast treasure that has come to us, and he had practically no inheritance of mechanical skill and mechanical apparatus. Small as his heritage of skill and knowledge may appear to us, to him it seemed great; and he promptly took possession of it, and endeavored to make himself so thoroughly master of it that he could use it effectively, and he resolutely set himself to investigate the great problems of nature with the aid of the rude instruments used by his predecessors and such improved apparatus as he could fashion for himself.

Tycho Brahe, the second child and eldest son of Otto Brahe, a Danish nobleman, who filled with credit an important office in the government, was born on the 14th of December, 1546, in what was then the Danish province of Scandia, but is now the southern extremity of Sweden. Otto Brahe, on the occasion of his marriage, had made an agreement with his brother George, who was childless, that George should adopt the first son that should be born to Otto. On the birth of Tycho, Otto and his wife refused to surrender their son to George, and he acquiesced in their decision at that time; but, on the birth of Otto's second son, George resolved to assert his claim to the elder son, and stole little Tycho. Thus it came to pass that Tycho was educated by his uncle, whose chief ambition was to have the boy thoroughly trained in philosophy and rhetoric, to fit him for a career of statesmanship.

Tycho began to study Latin at the age of seven, and entered the University of Copenhagen at thirteen. His early entrance at the university does not indicate any precocious or phenomenal cleverness; for we must remember that university requirements for entrance were then much more limited than now. The mathematical attainments of the average university student of that time may be gauged from the fact that in the University of Wittenberg the professor of mathematics was accustomed to encourage his students by assuring them that even the processes of multiplication and division in arithmetic could be learned by diligent students of average intelligence.

On the 21st of October, 1560, there occurred an eclipse of the sun, which was visible at Copenhagen, and Tycho was filled with amazement that the event could be accurately predicted. He obtained a Latin version of the astronomical works of Ptolemy, in which he diligently sought for the explanation of the methods by which such predictions were made; this book—marked and annotated in his boyish writing—is preserved as a priceless relic in the University of Prague. His mind was thus definitely turned to the study of the heavens, and from this time he spent his money and his energy in the pursuit of astronomical knowledge. His uncle used

every effort to divert him from natural science, which was then considered beneath the notice of a nobleman, and even engaged a tutor to prevent the youth from wasting, in so frivolous a pursuit, the valuable time that should be devoted to the serious study of philosophy and classical literature.

At the age of seventeen, Tycho began a series of systematic observations for the purpose of computing the places of the planets. His only instruments were a pair of compasses and a divided circle. Placing his eye at the joint of the compasses he opened the legs until they pointed to two stars; then he laid the compasses upon the divided circle, and thus found the angular distance between the two stars. In this way he soon found that the actual places of the planets differed widely from those recorded in existing books.

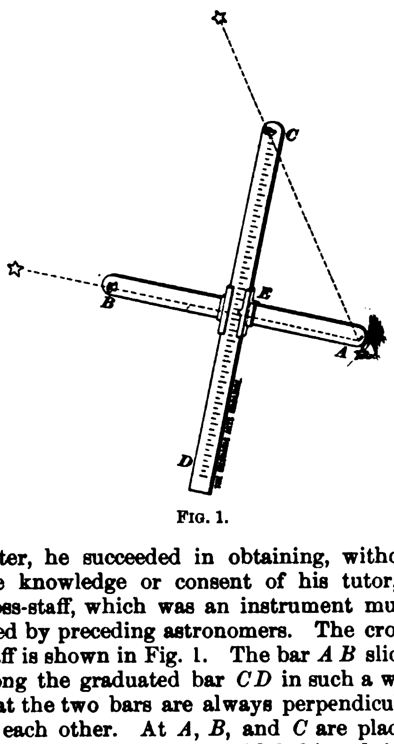


FIG. 1.

Later, he succeeded in obtaining, without the knowledge or consent of his tutor, a cross-staff, which was an instrument much used by preceding astronomers. The cross-staff is shown in Fig. 1. The bar *A B* slides along the graduated bar *CD* in such a way that the two bars are always perpendicular to each other. At *A*, *B*, and *C* are placed "sights," like those of an old-fashioned rifle. In making an observation, the eye is placed at *A*, and the instrument is so adjusted that one star is seen in the line *A C*, while another star is seen in the line *A B*. The distance *C E* is read upon the graduated bar *C D*, and then the angle *B A C* is found by reference to a table previously constructed. This primitive instrument, in the hands of so skilful an observer as Tycho, gave surprisingly accurate results. In using it, Tycho set the most excellent example of making systematic corrections for instrumental errors, and this example is followed by every astronomer today with the finest instruments that modern skill can make. In order to gain opportunities to use his cross-staff he had to exercise as much ingenuity to escape the vigilance of his tutor as was required in guarding against the errors of the instrument. However, he was soon relieved of all restraint upon his inclinations by the death of his uncle, which occurred when Tycho was nineteen. Tycho then proceeded to the University of Rostock. During his residence there he wrote some verses on the occasion of an eclipse of the moon, which happened on the 28th of October, 1566. In those verses he declared that the eclipse was to announce the death of the Sultan of Turkey, and as the Sultan was considerate enough to die at that very time, these verses gained for Tycho a good reputation as a reliable prophet. At this period Tycho had another very characteristic adventure—he lost a piece off his nose in a duel with another Danish noble, and made for himself an artificial nose of a composition of gold and silver. The artificial nose is said to have been as good as the original, though the historian has forgotten to state whether this remark was made by a partial friend or a satirical enemy.

About this time Tycho became interested in the pseudoscience of alchemy, which bears the same relation to chemistry that astrology bears to astronomy. It was inevitable that one so deeply interested in astrology should pay some attention to alchemy; for the astrologers and alchemists held that each planet was in some mysterious way correlated to a particular metal, and the two pseudosciences were very closely connected in men's minds.

He was recalled to the work in which he was destined to achieve such great results by a startling event that happened on the 11th of November, 1572. Returning to supper from his laboratory, he beheld an extraordinarily brilliant star where no star had been visible before. The appearance of the star was so unusual that he summoned his servants to assure him that he might trust his senses. New stars have frequently been observed, but we have no record of any at all comparable to this one in brilliancy and splendor; it was so bright as to be plainly visible in broad daylight. Immediately every person who made any pretense to be an astronomer began to speculate about this

prodigy, and to make observations and measurements of the position of the star. The observations and determinations of Tycho far surpassed all others in completeness and accuracy; indeed, he discovered everything that could have been discovered without a telescope. He proved that this brilliant object was a fixed star whose distance was far too great for measurement, and he carefully recorded the variations of its brightness.

These thoroughly scientific and very important conclusions were in his mind entirely subordinate to the great astrological significance of the prodigy. He says "the star was first like Venus and Jupiter, and its effects therefore will at first be pleasant; but as it then became like Mars, there will follow a period of wars, seditions, captivity and death of princes, and destruction of cities, with dryness and fiery serpents in the air, pestilence and venomous snakes. Finally, the star became like Saturn, which presages a time of want, death, imprisonment, and all kinds of sad things." In commenting on this passage, Kepler says, "If that star did nothing else it at least announced and discovered an astronomer." Tycho wrote a book setting forth his observations and conclusions regarding this star, but delayed the publication of it in deference to the wishes of his friends, who held the writing of books to be derogatory to the dignity of a nobleman.


NICHOLAS COPERNICUS.

This book, when published, attracted the notice of the King of Denmark, who invited Tycho to return to Denmark and deliver a course of astronomical lectures in the University of Copenhagen. Tycho accepted the king's very liberal proposal, and his inaugural lecture has been preserved. In it he speaks in glowing terms of the beauty and interest of celestial phenomena; he asserts the importance of continuous systematic observation; and he maintains that the science of astronomy is of immense practical utility as the only means of measuring time, and as enabling us to predict human fate from the motions of the heavenly bodies.

Now that our hero is fairly embarked on his career as an astronomer, let us consider what he derived from his predecessors. The astronomical works of Ptolemy, already alluded to, contained almost all the astronomical knowledge of the ancients that was of any value. In addition to these works he had the Alfonsine tables, which were calculated by order of Alfonso X of Leon and Castile, and published on the day of his accession in 1252; he also had the Prussian tables published at the expense of Duke Albert of Prussia, and revised from the calculations of Copernicus by Reinhold, who was professor of mathematics and astronomy in the University of Wittenberg from 1536 to 1553. Both of these sets of tables abounded in errors, many of which were quite serious; for example, in 1563 Tycho observed the close approach of Jupiter to Saturn, and found the time predicted by the Alfonsine tables to be a full month wrong, while the error in the time predicted by the Prussian tables amounts to several days. In theoretical astronomy the only advance upon the Ptolemaic system was the magnificent but uncorroborated speculation of Copernicus. The Copernican theory could then derive no support from the science of mechanics, which was still undeveloped, and it had not been sufficiently established by agreement with observations. Copernicus himself had made little effort to test his theory by observation. Indeed, he can base no claim to astronomical fame upon his skill or success as an observer; he lived in a latitude and climate unfavorable to such work; his instruments were of his own construction, and were far inferior to those used by earlier astronomers; he was an unskilful observer, and in one case made an error in the position of a star amounting to 40′, which is more than the apparent diameter of the sun. His pupil, Rheticus, urged upon him the importance of the greatest accuracy of observation. But Copernicus maintained that such accuracy was then unattainable and unnecessary, and that a rough agreement between the theory and the observed phenomena was all that could be expected until more accurate means of observation could be devised. He owes his exalted

position in the foremost rank of astronomers to his boldness and readiness as a theorist and to his ability as a mathematician. In common with all scientific pioneers he was a diligent and reverent student of the works of his predecessors, and was deeply read in the literature of mathematics and astronomy. It is sometimes assumed that he despised the ancient theories as mere idle superstitions, and he is honored because he broke loose from the shackles of those superstitions, and produced a complete new theory of the universe from his own brain, as Minerva sprang all-armed from the brain of Jupiter. Nothing could be farther from the truth. With characteristic modesty Copernicus claims no credit for his discovery, but attributes it as far as possible to the ancients; he quotes Philolaus and other Pythagoreans as authority for the doctrine of the earth's motion. Moreover, the theory propounded by him was by no means the complete Copernican system expounded in modern books. The one great principle upon which he insisted was that the apparent motions of the heavenly bodies are partly due to the motions of the earth; and he made no attempt to dispense with the Ptolemaic cycles and epicycles.

FIG. 2.

One grave objection to the Copernican theory was then and for long afterwards unanswerable. The essential point of his theory is that the motion of the earth causes an apparent motion of the heavenly bodies, and yet no such apparent motion of the fixed stars could be detected. If the earth describes a great orbit about the sun, the position of the earth at any time is separated from the position it occupied six months before by a distance equal to the diameter of this orbit; and by the reasoning of Copernicus this displacement of the earth should cause an apparent displacement of every star. Copernicus recognized this difficulty, but with wise and commendable audacity held to his theory, though unable to explain this apparently glaring contradiction. This is by no means a solitary instance of a true theory being in danger of rejection because of its conflict with the results obtained by experiment or observation, and the adherents of the despised theory require high courage and firm faith to withstand the sneers of contemptuous opponents and the irritating sympathy of skeptical friends. Of course, Copernicus could not have persisted in adhering to his theory if he had been convinced that it was contrary to the actual facts. He therefore took refuge in another speculation even more startling to the ancients than the doctrine of the earth's motion; he supposed that the fixed stars were so far distant that their change of position due to the earth's annual motion could not be detected, and he further supposed that the fixed stars were all at the same distance from the earth. The idea that the stars were at the same distance was the universal belief of ancient astronomers, but the speculation as to their enormous distances was simply suggested to him by dire necessity. He reasoned in the following manner: Suppose the earth in six months moves from E to E' (Fig. 3), and that S is the position of a fixed star; then the angle $E\,S\,E'$ measures the apparent displacement of the star due to the earth's motion. Now, if the distance $E\,S$ is 300 times the distance $E\,E'$, the angle $E\,S\,E'$ is less than 12′, and with the instruments of the time it was scarcely possible to detect so small a quantity. He believed that a time would come when, with improved instruments, astronomers would be able to detect this displacement of the stars. His hope has been fulfilled, his wild speculation of the enormous distances of the stars has been more than justified, but the belief that the stars were at equal distances, which he shared with the best practical astronomers of his day, has been shattered completely.

The book in which Copernicus published

these startling speculations excited little opposition at the time, chiefly because it was written in technical language, and could be read only by trained mathematicians.

The theoretical astronomy developed by Copernicus, however imperfect it may seem to us, was nevertheless far in advance of the practical astronomy that had for its object

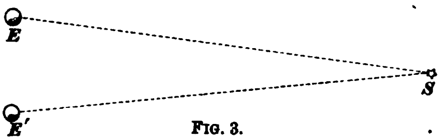


FIG. 3.

the making and recording of accurate observations. Further progress in theory could not be looked for until a practical astronomer should arise and, with improved instruments, make accurate observations by which the theory of Copernicus could be verified or corrected, and provide materials for those profound thinkers who were to correct and advance the theory.

This arduous task fell to the lot of Tycho Brahe, who was most admirably qualified for it. Tycho resembled Copernicus in his familiarity with and reverence for the learning of the ancients, but differed widely from him in other respects. Tycho was far inferior to Copernicus in power of keen speculation, but excelled in mechanical skill and in all those qualities that make a successful experimentalist. It is to be observed that Tycho entered upon his work with no intention of verifying the Copernican theory; indeed, he ultimately rejected that theory, and proposed a scheme of his own, which is shown in Fig. 4. His principal reason for rejecting the Copernican system was the enormous distances that it necessarily assigned to the stars, because there would thus be a vast void space between the stars and the planets, and he could not believe that nature would waste so much good space. His own system is a compromise between the Ptolemaic system and the Copernican. He supposed that the sun revolved in an annual orbit about the earth, and that the planets revolved about the sun, while the whole celestial sphere performed a daily revolution about the earth. The details of this system were never worked out, and it was never accepted by any competent astronomer.

In the year 1576 the King of Denmark gave Tycho the island of Hven as a site for a splendid observatory, for which the king supplied ample funds. The foundations of this observatory were laid with most imposing ceremonies. Here Tycho erected his great mural quadrant, which is illustrated in Fig. 2. By means of this wonderful instrument he was able to determine the altitudes of the stars with far greater accuracy than had ever before been attempted. In the illustration Tycho is seen using the mural quadrant, with the aid of his pupils.

Tycho was now in the zenith of his fame; students flocked to study under him, and the king defrayed the vast expenses of his great establishment by lavish grants from the royal purse. In the seclusion of his island observatory, he pursued his work for twenty busy years, and accumulated a splendid series of observations far surpassing in exactness anything that had been done by his predecessors. His fame rests solely upon the completeness and wonderful accuracy of these records.

In 1596 a new king ascended the throne of Denmark, and he withdrew the grants to Tycho. Tycho therefore left Hven and went to Bohemia, where he died in 1601.

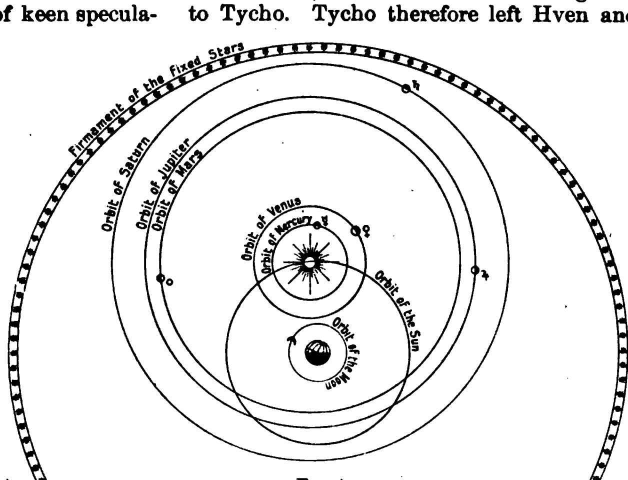


FIG. 4.

Tycho's modern rival bears the euphonious and easily remembered name of Mahámahopadhyáya Samanta Sri Chandrasekhara Simha, and is a native of India. The Hindus have never adopted the Gregorian calendar, and the errors of their own calendars have accumulated to an intolerable extent, and great confusion arises from the

fact that no two of their almanacs agree. To correct their calendar and regulate their religious observances, it was necessary to determine the exact length of the year, and this can be done only by astronomical observations. This Hindu astronomer of the nineteenth century set himself to this task with even less external assistance than Tycho; he also had to fashion his own instruments, but without the aid and encouragement that Tycho received from a generous king and from pupils that were themselves able mathematicians and skilled astronomers. The Hindu astronomer's store of inherited astronomical knowledge was altogether insignificant, consisting merely of rude records dating from the twelfth century and earlier. Any one familiar with the routine of a well-equipped observatory will have a feeling of sympathy for this Oriental toiler constructing his own instruments and recording his observations upon a palm leaf. His success can be estimated from the following figures: The errors in his determination of the sidereal periods of the sun and moon are 206 seconds and 1 second, respectively; in determining the inclinations of the orbits of the planets to the ecliptic, his greatest error is in the case of Mercury, where his error is about 2 minutes. The system that he proposes closely resembles that of Tycho.

Surely these men are worthy of immortal honor for their devotion to the pursuit of knowledge, and for their patient endurance in the work of wresting from nature the secrets by which millions of their fellow men may regulate their daily routine.

MAGAZINE SCIENCE.*

(*By permission of "The Locomotive."*)

A. D. Risteen.

A JUST CRITICISM OF A FEW OF THE MISLEADING SCIENTIFIC ARTICLES THAT HAVE APPEARED RECENTLY IN SOME OF THE MOST POPULAR MONTHLY MAGAZINES.

ALL science may be divided into two broad classes; namely, science that *is* so, and science that *isn't* so. The first of these divisions is what we expect to find in the standard treatises that are written by eminent men, and in the articles that appear in high-class scientific periodicals. It is true that we are sometimes disappointed in this expectation, for occasionally we find some of the science that *isn't* so, even where we should expect it least. The kind that isn't so is far easier to write; and as the other kind can be produced only by great labor, it is not strange to find our most trusted authorities occasionally going astray, and giving us a few paragraphs of foolishness now and then.

Beautiful examples of the kind of science that *isn't* so can be found in the newspapers, and in a good many of the so-called "popular" books. Such books are written, for the most part, by men who have an idea that that mythical individual, "the average man," cannot understand the real facts of nature, and they appear to think it necessary to tone down those facts and smooth them off and fix them up and elucidate them by "popularized" illustrations that are more or less inaccurate, until their books, when they are completed, contain much of the second kind of science; that is, much of the science that *isn't* so. All of which is reprehensible in the extreme. It is also altogether unnecessary, as is evident from the few really first-class popular books that have been produced—Tyndall's "Heat Considered as a Mode of Motion," for example.

To the two classes of science into which most writings can be divided, and which are mentioned above, an intermediate division, or *subclass*, may be conveniently added, so as to include the science that is *almost* so, but *not quite*. For science of this sort we

*This article is worth reading twice. It was not written specially for these pages, but as an editorial for "The Locomotive," of which Mr. Risteen is the very able Associate Editor. It is, however, peculiarly suitable for publication here, because one of the main objects of THE MECHANIC ARTS MAGAZINE is to teach clearly the science that *is* so. This is, in itself, no easy task, but it is made infinitely more difficult than it really should be by the publication in newspapers—and especially in the Sunday editions—of much sensational science that *isn't* so. The unfortunate part of it is that, whereas the Sunday paper comes weekly and is read and believed by the million, the educational periodical comes but once a month and then only in thousands. We consider it the bounden duty of every reader of this article to persuade at least one other person to read it.—ED.

propose the name "Magazine Science," since it is in our leading magazines that such science is nowadays most prominently put forth. Magazine science, as thus defined, may degenerate at times into the kind of science that is *not* so, but it seldom rises so as to be clearly in the class that *is* so.

It isn't long since "Harper's Magazine" published a roseate article on the Jacques carbon battery, in which the vast possibilities that were said to be before that battery were suggested in the most hopeful terms. This battery attracted a great deal of attention from the general public, and with the apparent endorsement of a magazine as favorably known as Harper's, it would have been easy (we should think) for an unscrupulous man to have organized a company that would have taken many good dollars from men who could not afford to lose them. We do not mean to imply that Dr. Jacques had any such idea in his head; but we *do* mean that a magazine that is well known and widely read and trusted takes a great responsibility when it publishes an article that leads thousands and thousands of readers to believe that a great and probably profitable invention or discovery has been made, when it really has not been made. We discussed the Jacques carbon battery in the issues of "The Locomotive" for August and September, 1896; and the correctness of our view of the matter has been substantiated by the fact that the carbon battery has now fallen, to all appearances, into innocuous desuetude.

A recent and widely-discussed example of "magazine science" occurs in "McClure's Magazine" for March of this year, where Mr. Ray Stannard Baker writes of "Liquid Air." The article contains much that is of deep interest, and some things that are not so. With one or two exceptions, the portions that treat of the *experimental* data are apparently correct, while the portions that deal with theoretical principles are sadly in error. This is probably due to the fact that neither the writer of the article nor the experimenter (Mr. Charles E. Tripler) are very well informed on the subject of thermodynamics.

This article on liquid air has already received much rough treatment from the technical journals and the newspapers, and we have no desire to add to the condemnation that has been heaped upon it. We have received a good many inquiries about it, however, and our readers appear to expect us to go on record in the matter upon one side or the other, and so we shall give our views as briefly as possible.

The part of the article which has provoked hostile criticism is that in which Mr. Tripler speaks of running an engine with three gallons of liquid air, and using the power so developed to drive a compressor which produces ten gallons without being supplied with any mechanical energy save that obtained from the three gallons used in the engine. Many of the critics of the article appear to scent a perpetual-motion scheme here, in spite of Mr. Tripler's earnest disclaimer. Mr. Tripler says that the heat *of the surrounding atmosphere* is boiling the liquid air in his engine and producing power, just as the heat of coal boils water and drives off steam, which develops power in the steam engine. He says that he is merely converting the natural heat of our atmosphere into mechanical energy, instead of following the usual plan and obtaining the heat to be so transformed by means of the combustion of coal. This explanation is a peculiarly seductive one, because to the general reader who has not made a study of the theory of heat, it appears to be rational and by no means impossible, nor even improbable. There is an obstacle in the way of such a project, however—an obstacle known as the "second law of thermodynamics."

The transformation of heat into mechanical energy is governed by two general laws. The *first* of these laws states that whenever such a transformation does take place, whether in a steam engine or a gas engine or a liquid-air engine or a heat motor of any other kind, a perfectly definite amount of heat disappears for every foot-pound of mechanical energy that is produced. This law is quite well known, and there is nothing in the article in "McClure's" which contradicts it in the smallest particular.

The *second* law governing the transformation of heat energy is by no means as easy to state. It may be presented in several different forms, whose equivalence is not at all obvious. In the simplest of these forms, the second law consists in the statement that heat always tends to pass from a hotter body to a colder one, and that it cannot be made to pass in the reverse direction (that is, from a colder body to a hotter one) without the expenditure of energy. (When so stated, the law may be compared, for the sake of clearness, with the fact that water always tends to pass from a higher level to a lower one, and that it cannot be made to flow in the opposite direction without the expenditure

of energy, by a pump or other device.) Although the "second law," when presented in this form, may appear absurdly simple, yet its consequences are by no means easy to follow, and many of them are so hidden that much patient study is required to trace them out. Without going into the matter more deeply, we shall state that one of the many important consequences of this "second law" is, that it is impossible, by means of any reversible mechanical device or combination of devices, in which a working body is subjected to a cyclical change of temperature, to derive continuous mechanical effect from air or any other substance, by cooling it below the temperature of the coldest of the surrounding objects. We have stated this consequence in a rather ponderous way, because when we are criticising another fellow we always want to be quite exact in our own statements. The untechnical reader need not trouble to cipher out just what the foregoing statement means, provided he is willing to accept our assurance that Mr. Tripler's apparatus is the equivalent of the kind of apparatus there described, and that the thing he is trying to do is the very thing that is there declared to be impossible. He subjects a given mass of air to the following operations: Firstly, he cools it and compresses it, until it liquefies. Secondly, he allows the air thus liquefied to evaporate and expand in an engine. Thirdly, in the course of this process he claims to have gained a certain amount of mechanical energy, and he states that the mechanical energy so gained is obtained by the absorption of heat from the surrounding atmosphere, and the transformation of the heat so absorbed into work. That is, he claims that the mechanical energy that he gains is obtained by cooling a certain portion of the ambient air *below the temperature of the rest of the ambient air;* which is precisely what the second law of thermodynamics says cannot be done by such means as he employs.

In reply to these considerations it may be urged that all human knowledge is liable to additions and corrections, and it may be claimed that Mr. Tripler has discovered that the second law of thermodynamics is unsound, and that he has shown how it can be violated. Our rejoinder to this argument would be as follows:

1. The second law of thermodynamics has been subjected to the most searching tests, by many physicists and mathematicians of undeniable ability, and yet it has withstood all these tests perfectly. It has predicted many previously unknown facts which have afterwards been verified by direct observation, and it has never, heretofore, been found to be at variance with experience in the smallest particular.

2. We believe that Mr. Tripler is not thoroughly informed on the subject of thermodynamics, for the following reasons: (*a*) He speaks of the "absolute zero" as "Dewar's," whereas the fact is that Dewar has had nothing to do either with the theory of the absolute zero, or with the experimental determination of its position. The theory is due to Lord Kelvin, and the experimental determination of the position of the point is due to Kelvin and Joule. (*b*) He says that "we don't yet know just how cold the absolute cold really is . . . but Professor Dewar thinks it is about 461 degrees below zero, Fahrenheit." Now, this is literally correct, and yet it is hardly what a man would say, if he were aware that our uncertainty about the position of the absolute zero can hardly amount to a third of a degree. The language is that of a man whose knowledge of the theory comes from some popular lecture or article, rather than from a sound knowledge of what the absolute zero is, and how and by whom its position was determined. (*c*) On the last page of the article in question it is implied (presumably with Mr. Tripler's sanction) that the efficiency of a reversible cyclical heat engine may depend upon the nature of the working body, it being particularly intimated that air is superior, as a working body, to water and steam. Now this is one of those plausible looking things that further study shows is not so; and Carnot taught us, in the early part of the present century, that the efficiency of the engine does not depend in the least degree upon the nature of the working body, being the same whether that body is air or steam or ether or bisulphide of carbon, or anything else. (*d*) Except in the more advanced treatises, writers of books on heat engines and thermodynamics have seldom treated the "second law" carefully enough and fully and clearly enough to give the reader a good understanding of it. This is unfortunate, and it doubtless explains why so many otherwise capable inventors repeatedly try to do things that are opposed to this law. The "second law" ought to be popularized as the first one has been, so that such intelligent and capable men as Mr. Tripler might have an opportunity to inform themselves about it, without having to study

higher mathematics, and perhaps some foreign language also, to do so. A book is wanted on this subject, and if somebody doesn't write it pretty soon, we may be forced to write it ourselves.

Now, if it be admitted (1) that the "second law" of thermodynamics has been sorely tried and yet never before found wanting, and (2) that Mr. Tripler is probably not well informed concerning this "second law," then the probability that he has demonstrated the falsity of this law becomes very small, and the alternative probability, namely, the probability that his reputed production of ten gallons of liquid air from three is to be explained in some other way, becomes correspondingly greater.

It will be observed that we have adhered, in this discussion, strictly to the technical and scientific aspects of the problem, and that we have scorned to make use of the suggestion raised by our esteemed contemporary, the "American Machinist," which says that "Mr. Dickerson, Mr. Tripler's most trusted assistant, was compelled to acknowledge, at a recent meeting of the Franklin Institute, that the statement (about producing ten gallons of liquid air from three) was untrue." We trust that our forbearance in not raising this point will be appreciated by all concerned.

Another recent example of "magazine science" will be found in "The Century" for April of this year, under the heading, "Absolute Zero." The author of this article tries, at the outset, to give his readers an idea of the kinetic theory of gases—a theory about which he appears to have some very hazy ideas. He compares the molecules of a gas with a lot of little balls, in the following language: "Picture to your mind a room in which there are small balls all alike, each ball endowed with bitter hatred of all other balls of its own kind, and an intense desire to get as far from them as possible. The balls will assume positions equidistant from one another in every direction, and the outer ones will press against the walls of the room with all the force they may possess in their effort to get away from their kind. If more balls are forced into this room, all the balls must readjust their positions and come nearer to one another. The result of forcing them nearer together will be to produce a greater tendency to go farther apart, and greater pressure against the walls of the room. The balls represent molecules of gas—for example, oxygen. The gas presses against the walls of its retaining vessel *because of the repulsion between the molecules.*"

As the article here under examination has not attracted the same attention as the one in "McClure's," and as it does not hold out the same extraordinary possibilities in the way of producing power and otherwise revolutionizing things, we shall not need to discuss it at any great length. We cannot allow our author, however, to speak of molecules as "becoming accustomed to one another," or as being "endowed with bitter hatred," or as having "intense desires" to do things, without a passing expression of our contempt for all such puerile phrases. A magazine of the standing of "The Century" should not admit such wishy-washy language to its pages. Its readers are not children, and any man who would take any interest whatever in the "absolute zero," would be able to understand good straight English.

Passing now to the question of *accuracy*, we find that the passage quoted above contains a serious error of fact. "The gas presses against the walls of its retaining vessel," says our author, "*because of the repulsion between the molecules.*" Now, one of the most elementary teachings of the molecular theory is that this is not the case at all. In fact, the molecules of bodies never do repel one another, so far as we are aware, except possibly in the case of hydrogen. The evidence of such repulsion even in hydrogen is very weak indeed, and in all other bodies that have been investigated the molecules *attract* one another. The pressure that gases exert against the vessels containing them is due to the collisions of the flying molecules with the walls of those vessels. The intermolecular forces, instead of *causing* that pressure, actually tend to *diminish* it to a slight extent. A writer who would fall into an error as elementary and as gross as the one here signalized, has no business to write articles on these matters for the "instruction" of the public. We are not surprised, after noting this blunder almost at the outset, to find other meaningless or erroneous phrases later on. For example, on page 884, the article refers to the diminution of the electrical resistance of pure metals at low temperatures, and goes on to make the meaningless suggestion that "perhaps electrical waves traverse external space without loss of energy." If he means that a vacuum will allow of the passage of an electric *current* without resistance, he is writing arrant nonsense. If he means that perhaps waves of electrical *displacement* can traverse external space without resistance, he is only putting forth as his

own crude guess a proposition that has been established ever since Maxwell's electromagnetic theory of light was first accepted by physicists. Besides, what has temperature to do with space, anyhow? How can a vacuum be hot or cold?

The illustrations used in "The Century" article were made from photographs taken in Mr. Tripler's laboratory; and in the closing paragraph of the article we find that its author is more or less tinctured with Triplerism. He just nibbles at it a little bit, but is too wary to commit himself to it fully, as "McClure's" writer did. The paragraph is as follows: "Eager minds are striving to invent grander uses for the greater forces which the recent results place at our disposal, and some think they can forsee the day when the power stored in these abysses of cold will enable man to do that which is now looked upon as impossible, or at least chimerical."

"Magazine Science" is a wondrous thing.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Dreyfus Case.

THE French have a proverb which recommends people to "wash their dirty linen at home." Self-respecting and patriotic Frenchmen must sincerely regret that modern newspaper methods have recently debarred their country from following this excellent advice. From whatever point of view the celebrated Dreyfus case is regarded, its public discussion has become for France a public scandal. Dreyfus may be an innocent man, unjustly condemned, either through carelessness, prejudice, or revenge, to a cruel fate. Or, in the face of strong evidence to the contrary, it is possible that he is guilty, and therefore deserving of a punishment to which, however, he was illegally condemned on the strength of secret evidence. In either case a tissue of trickery, deceit, and fraud has been revealed to the world; and the stains and rents of the national garments have been publicly displayed, instead of being sheltered in the decent privacy of the home laundry.

In October, 1894, a document was sent to the officials of the French secret service by a spy who had access to the rooms of the German embassy in Paris. This letter, or "bordereau," was written in French, and alluded to important information about military matters which had been imparted to Herr Schwarzkoppen, the German military attaché. These items of information could have been known only to officers of the French army. A French officer a traitor! betraying professional secrets to Germans! It seemed incredible.

Captain Alfred Dreyfus, a young officer of marked ability, was of Jewish birth. A strong anti-Jewish prejudice exists in Paris, and many were jealous of the success of one of the hated race. Suspicion was cast on the Jewish officer, whose handwriting was said to resemble that of the letter, or "bordereau." Specimens of his writing were procured and submitted to five experts in graphology. Of these, two detected a resemblance to the "bordereau," two denied that there was any likeness, and the fifth thought that the "bordereau" might have been written by Dreyfus in a disguised hand. Dreyfus was arrested, and accused of high treason. During the ten weeks of imprisonment which preceded his trial by court martial he was treated with great severity, as if his guilt were already proved. The prejudice that existed against him, even in the highest quarters, was very strong. General Mercier, then the minister of war and head of the army, declared three weeks before the court martial was held that Dreyfus was guilty.

The trial took place in part behind closed doors. Neither Dreyfus nor his counsel knew of the introduction of any testimony besides the now famous "bordereau"; and the world supposed that he was convicted on the evidence of that document alone. He was condemned to a disgraceful expulsion from the army, and to banishment with imprisonment for life. Dreyfus appealed to the military council, which is empowered to revise the decisions of courts martial. This court reaffirmed the verdict without examination; and on January 5, 1895, Dreyfus was publicly degraded. A special law was passed which provided for his solitary confinement on Devil's Island, a little spot of land off French Guiana, on the northeast coast of South America. To the last moment Dreyfus

protested his innocence of any crime against the country which he had loved and served faithfully. He charged his wife to devote her life and fortune to the discovery of the truth and the exposure of the traitor.

More than a year went by. In 1896, Colonel Picquart, an officer who believed in the guilt of Dreyfus, was appointed to a position in the information department of the army. He found among the papers in his charge grave reason to suspect that another officer, Count Ferdinand Walsin Esterhazy, was a spy in communication with the spies of the German and Italian governments. Investigations of his character and his antecedents confirmed these suspicions. Colonel Picquart also observed a close resemblance between the handwriting of Esterhazy and that of the "bordereau"; and he began to fear that an outrage of justice had been committed. He urged a revision of the Dreyfus trial in the interests of truth and honor. But Esterhazy had powerful friends; Picquart's investigations were suddenly stopped, and he himself was sent to a distant part of France, and thence to Africa. His successor in the information department was Colonel Henry, a man of strong anti-Jewish tendencies. General Mercier, the minister of war, had been succeeded by General Billot, who was dissatisfied with the appearance of the Dreyfus affair at the stage it had reached. To quiet his suspicions, Col. Henry produced a letter which he declared to be part of the secret evidence against Dreyfus. It appeared to be from the German to the Italian military attaché in Paris, and in it Dreyfus was specifically named as a spy.

The discoveries, with regard to Esterhazy, had not been made public, yet uneasiness was felt by all concerned in the conspiracy. The possessor of a guilty secret should be silent as the grave if he wishes to protect himself from discovery. His greatest danger lies in the restlessness which makes him endeavor to strengthen his position by drawing attention to the points which—in his opinion—are in his favor. Dreyfus, in his miserable captivity, would not have been forgotten by his wife and kindred; but they might have been unable to produce important evidence on his behalf if certain officials of the information department had known how to hold their tongues. In September, 1896, in order the more certainly to divert suspicion from Esterhazy, these officials procured the publication in the "Eclair," a Paris newspaper, of an article which stated that the "bordereau" had not been the only evidence produced against Dreyfus at his trial, as was supposed to be the case. Other documents had been secretly supplied to the officers who composed the court martial; but they had not been shown, as the French military code of justice requires, to the prisoner and to his counsel. These documents were announced to have been of such a character that in the interest of the nation the department had thought it unsafe to make them public. Thoughtful people were shocked at this open acknowledgment of illegal action in connection with Dreyfus, and the belief that he had been the victim

DEVIL'S ISLAND, SHOWING DREYFUS' HUT *, WITH SURROUNDING STOCKADE, THE QUARTERS OF HIS GUARDS, AND THE WATCH TOWER ARMED WITH A HOTCHKISS GUN.

of a conspiracy gained ground. Madame Dreyfus was quick to take advantage of the admitted breach of law, and appealed for revision of her husband's sentence. Her appeal was refused on the ground that the government itself had no right to discuss a verdict regularly given. Lovers of justice, in France and out of France, protested that, if a verdict had been procured by means of a breach of law, it was not a "verdict regularly given."

But the article in the "Eclair" indirectly rendered another service to the friends of Dreyfus. It published the text of the "bordereau," of which Dreyfus was supposed to be the writer. A pamphlet appeared in a few days which disputed the accuracy of this copy of the "bordereau." Thereupon the "Matin," another Paris newspaper, published a photographic facsimile of the original document. A banker bought a copy of this facsimile, and recognized in it the handwriting of one of his former customers, who was none other than Esterhazy, on whom suspicion had already been thrown by Picquart. Public opinion demanded that Esterhazy should be tried by court martial. The trial took place in January, 1898, and was opened in public; but the testimony of the most important witnesses—of Picquart, who had been sent for from Tunis to give evidence, and of the experts in handwriting—was given behind closed doors. Count Esterhazy was acquitted, yet the suspicions of those who had doubted him were strengthened by the secrecy which had characterized his trial.

Meantime, the Dreyfus affair had been discussed by the Chamber of Deputies. The prime minister and the minister of war declared that they had positive proof of his guilt, and on this declaration the Chamber upheld the verdict of 1894, and refused to grant revision.

The famous novelist, Emile Zola, in common with many other Frenchmen of the highest character, was roused to indignation by the partiality shown in connection with the trials of Dreyfus and of Esterhazy. Zola wrote an open letter to the president of the French Republic, denouncing the officials of the war department who had been responsible for the conduct of the two cases, and accusing them of deliberate and intentional injustice. Zola was prosecuted, and, after a stormy trial in which his witnesses were repeatedly silenced, he was condemned to a year's imprisonment. He appealed to the Supreme Court of France, the "Court of Cassation," and the decree against him was annulled on a technicality. He was again prosecuted, but not appearing in court at the appointed time he was condemned by default, and quitted the country.

Throughout the year 1898 the question of the revision of the sentence of Dreyfus continually agitated Paris. The suspicion, the fear that he had been the victim of a conspiracy in the highest quarters, became almost a certainty. Picquart, the ex-official of the information department, was not a friend of Dreyfus; he had no personal connection with him; but with a love of truth and justice, and a noble disregard of his own interest, he would not let the matter rest. In July, 1898, he declared that an important document, used in the trial of Dreyfus, had "all the characteristics of a forgery." He was arrested and imprisoned; but his words had had weight. M. Cavaignac, who was minister of war during the summer of 1898, while the short-lived ministry of M. Brisson was in power, obtained secret information with regard to the document, by means which are still unknown; and by cross-examination forced from Colonel Henry the confession that the letter in which Dreyfus was named as having dealings with foreign spies was forged by himself, in the summer of 1896, in order to convince General Billot of the convict's guilt. Henry was arrested and imprisoned, and the next morning he was found dead in his cell. Who can doubt that he carried to his grave secrets which would have ruined many a reputation? The conclusion was inevitable that the evidence against Dreyfus must indeed have been weak when it was necessary to have recourse to forgery in order to keep him in the captivity to which he had been condemned by cruelty and fraud.

Henry's death took place on September 1, and added fuel to the flame which already raged. The struggle between the advocates and the opponents of revision became intensified. The position of the former was greatly strengthened; the latter exhausted all their ingenuity to prevent or delay the action, or to change the character of the court by which the sentence should be revised. Noble men have followed in the steps of Picquart, have sacrificed their careers, braved the insults of the mob (who idolize the army and feel that its prestige is threatened), and have publicly espoused the cause of truth and justice. If France must blush for the revelations of trickery and dishonor in connection with the Dreyfus case, she should also be proud of the

men who, without noise or clamor, have stood for upright dealing. They have set their faces like a flint, and declare that justice shall be done—not for a friend or a brother, but for the son of an alien race; for a fellow citizen who claims to have suffered injury at the hands of France. For the sake of France, whose fair name has been aspersed, they say that the wrong must be repaired.

At the present time the case of Dreyfus is being considered by the Court of Cassation, a body of noble, upright, and honorable men who care nothing for public favor and have no guilt to hide. But how little can be done for this poor prisoner if he *should* be declared to be innocent! None can give back to him the bitter, wasted years, the lost career; none can restore the broken health, the shattered nerves; none can blot out the memories of anguish and despair which threaten to overshadow the remainder of his mortal life!

THE KITCHEN FIRE.

Mrs. Henry Esmond.

THE PRINCIPLES UPON WHICH A STOVE IS CONSTRUCTED—THE MEANING OF DRAFT—HOW TO LAY THE FIRE—OPERATION OF THE DAMPERS.

THERE are certain principles connected with the building of a fire that should be understood by every one; this, not only because the subject itself is interesting, but because there is at least *one* fire in every house, and if that—the kitchen fire—fails on occasion to burn properly, there are chances of a good meal being spoiled, and the general temper of the "house" unpleasantly ruffled. Especially, therefore, does it amount of heat required. For convenience, our kitchen fires are usually enclosed in an iron box, called a *stove*. As the conditions for making a fire are the same in all enclosed spaces, we will use, for the sake of illustration, a candle, and a lamp chimney to enclose it. Light the candle and stand it on the table; hold the chimney over it a few inches above the table, as in Fig. 1; the candle burns freely. If, now, the hand is held

FIG. 1.

FIG. 2.

FIG. 3.

behoove the good housewife to know all there is to know about the subject, that she may be in a position to wisely coax the sometimes refractory stove, and so maintain her very excellent reputation as a cook.

To make a fire we must have something to burn—either wood, coal, gas, or oil; in short, we must have *fuel*, which means anything for making a fire with. We all know that air is necessary to keep a fire burning, and that we must be able to regulate the supply of air according to the

over the opening at the top of the chimney, there will be noticed an upward current of decidedly hot air, while at the lower opening it can be shown that the air is just as cool as that in the room; this shows that hot air rises. If the chimney is set down on the table, as in Fig. 2, the flame will soon go out, though there is still the opening at the top; this shows that where there is a fire in an enclosed space the air to keep it burning goes in at the lower opening, and that the heated air and the products of

combustion rise and pass out at the upper opening. Now, if we hold the chimney over the candle, as in Fig. 1, and then, while the candle is burning, place a sheet of glass on the top of the chimney, as in Fig. 3, the flame will go out in a very short time. By this we learn that it is necessary to have free *circulation* of air through the flame, otherwise it will go out; in other words, we must have "good draft." The word *draft* means the act of drawing, or pulling, and is used here because, when heated air rises, cold air is forcibly drawn, pulled, or sucked in to take its place.

We often hear the expression "the stove doesn't draw well," or "the chimney hasn't a good draft," which mean that there is some obstruction, which either prevents the air from going *into* the stove freely, or else prevents it from passing *out* freely. A coal stove consists, as shown in Fig. 4, of a large iron box, with a space at one end lined on three sides with firebrick *b*, and the front and bottom of which consists of iron bars with openings between. This space is called the *firebox*, because in it the fire is built; the air goes into the firebox at either the bottom or side, or both. Outside of the firebox on the front of the stove is a slide *s*, called the *front damper*, which may be opened or closed as more or less air is needed. Directly behind and close to the firebox is another iron box *c*; this is the oven, and it is set into the stove in such a way that there is a space *d* between the top of it and the top of the stove, and also on all sides except that which comes directly next to the firebox. In the chimney, at *g*, is an opening controlled by another slide, called the *chimney damper*, which controls the opening into the pipe connecting the stove with the outer air. This chimney damper and the front damper are the only ones that are absolutely necessary, so far as the fire is concerned, but we find here still another, *h*, called the *oven damper*, the use of which will now be explained.

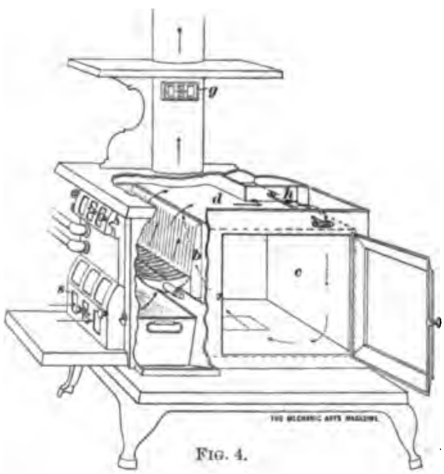


FIG. 4.

If we light a piece of paper and place it in the firebox, we notice that when the oven damper *h* is open the flame is drawn across the top of the oven, direct to the chimney. Closing the oven damper, as in the figure, we find that the opening leading to the chimney is thereby closed, and that the flame is now drawn across the top of the oven, down the opening at the end, under the oven and up behind it, finally reaching the chimney; we thus understand that by the closing of this oven damper the heated air is compelled to go around the oven before reaching the chimney, and that in this way the oven is heated. The arrangement of these dampers differs in different cooking stoves, but the principle is always the same. There *must* be a lower or front damper to control the supply of fresh air, and there *must* be a chimney damper to control the escape of the smoke, gases, etc., and, in order to heat the oven, it is necessary to compel the heated air to pass around the oven on its way to the chimney, and therefore there must be an oven damper.

When the fire is first lighted, all the dampers should be opened, so as to allow plenty of fresh air to go in, and all the smoke, etc., to get out freely, it being understood that when the oven damper is open the smoke has free and direct access to the chimney. When the fire is burning freely, the oven damper is the first closed, so that the oven may be heated.

To build the fire, paper, soft wood, hard wood, and coal are generally used, though shavings are frequently substituted for the paper. The paper is put in first, and is crumpled to make more air spaces within it, and thus to cause it to burn more freely; next comes the soft wood, which, having a higher kindling point than the paper, is heated to the necessary degree by the burning paper; this soft wood has coarse, loosely packed fibers, the spaces being filled with air when the wood is dry; over the soft wood should be placed some hard wood; this, having finer fibers, more closely packed, contains less air, and so does not burn as easily as the soft wood; the coal comes on top of all, and, having a higher kindling point than either kind of wood, must be heated to the kindling point by their burning.

The wood must be arranged slightly crosswise, that the air may circulate around it, care being taken at the same time to keep the ends close to the sides of the firebox, that the coal may not drop through to the grate unburned.

When the coal has become well kindled, the oven and the chimney damper should be closed more or less, according to the heat required. The chimney damper is so arranged that it cannot be entirely closed; if it could, ignorant or careless persons might close it, and then the fire would not burn, or, if already burning, the poisonous gases from it would escape into the room, to the danger of the occupants of the house, especially if they are sleeping. After the fire has been burning for some time, the ashes collect at the bottom of the grate, and must be poked or shaken out, otherwise the air will not reach the hot coals, and soon the fire will go out.

GOOD WORK.

GOOD work does not necessarily mean work of great accuracy. For instance, it is possible for a wooden shed to be a good shed, well put up, strong, serviceable, and sightly, and yet no single dimension in it be exact to any drawing or to any preconceived idea of what it was to be; here, an inch or so either way is of no importance whatever. So in the machine shop a thousandth of an inch more or less in the diameter of a 6-foot belt pulley is practically nothing, that is, it is not worth consideration; on the other hand, the same amount may be a good deal on the diameter of a 3-inch shaft, when a forcing fit is in question. As a general rule, serious disaster is bound to follow an attempt to translate "good work" into "close fit." The attempt has proved before today that the hole for a 1-inch spindle to run in must be *more* than 1 inch in diameter, or it will seize, and much damage be done. The true meaning of good work has often been brought home to the too accurate workman by the parts of a machine seizing in this manner. The good workman should know when a specially fine fit is necessary, but he should also know when and how to render it unnecessary. These are points that the designer should bear in mind, too, no matter *what* he is designer of.

On the majority of machines, great expenditure of skilled labor is wasted, and is evidence of bad practice. Undue anxiety to use the best possible material may also be bad practice. It generally pays better in the long run to use ordinary material—good, dependable, commercial material; true, it may be necessary to employ more of it, but even then it will pay, not only because the first cost is less, but because, in case repairs are necessary, the commercial material can be had at once—taken from stock, probably—whereas the special, high-grade material will have to be made and will cost very dear in delays. In many cases, the extra weight of the cheaper material may be a virtue, and it is certainly *not* good work to put in a great weight of costly stuff when the cheaper material possesses a margin of strength beyond any other part of the same structure.

Now, there are machines upon which a great expenditure of time and skilled labor is not wasted. Two watches of the same make, that are apparently identical, will have very different values, according to the skill with which they are made, and the fineness of their finish. Whether or not the watch leaves the workman's hands with perfectly balanced corrections may seem to be somewhat a matter of chance, but we may be sure that no badly made watch will run well enough to receive a high certificate. Here, with good work attempted throughout, a little extra and expensive final finish may pay handsomely.

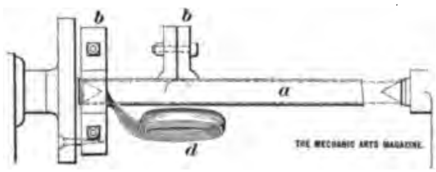
In dealing with artisans, the great difficulty is to get a man for a special job who is exactly suitable for it. For instance, a really first-class cabinet- or pattern-maker may be quite useless for a rough carpentry job, because he has acquired certain habits and has become by nature too accurate to make a paying job of the rough timber shed. Again, the man accustomed to rough work is often incapable of comprehending what great accuracy means where it is really needed. There is an old saying, "You cannot make a silk purse out of a sow's ear." But it is poor policy to degrade the sow's ear. There is far too much of the silk purse about some men. Good work always represents the *correct* degree of accuracy.

GOOD SCHEMES

TO HOLD A THIN TUBE IN A LATHE.

W. H. D. Bogue, Chicago, Ill.

With the hope of adding to the interest of the Good Schemes department, I enclose a sketch of a method of holding thin tubing in a lathe, that I think will be of use to some. Referring to the drawing, *a* is a very

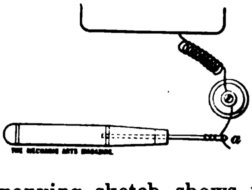


thin tube, upon one end of which it is desired to cut a screw thread; wrap the other end of the tube with tape *d* and grip in either a wooden or a metal chuck *b*; it will be found that by this means a perfectly secure hold is obtained. The other day I was watching a lathe hand at work on some bicycle necks, and I noticed he had a hard time keeping the tube from slipping; at my suggestion he tried the above scheme, and said it was just the thing, and that he had no more trouble. So I pass it on, for the benefit of others.

NEEDLE FOR ELECTRICAL WORK.

R. L. Wheeler, Peoria, Ill.

Sometimes in electrical work, such as assembling meters, etc., it is very difficult to connect the fine wire that leads the coil to some other attachment, the connection being made by a screw. A pair of extra-long tweezers may seem the proper thing, but where there is little room to work they will often slip off. The accompanying sketch shows what I have been using for the past few months with most satisfactory results. Take a piece of soft-iron wire about $\frac{3}{64}$ of an inch in diameter and $1\frac{3}{4}$ inches long; flatten one end, as at *a* in the sketch, and make a hole in it large enough to receive the wire easily, and furnish the other end with a wooden handle. With this tool it is possible to reach any

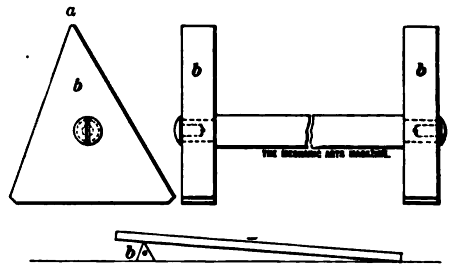


place that a screwdriver can touch, and to hold the wire firmly. After the wire has been secured in the desired position, the needle is loosened by simply untwisting.

SELF-ADJUSTING DRAWING-BOARD REST.

F. L. Nichols, Baltimore, Md.

Wishing, as no doubt other readers of The Mechanic Arts Magazine have, for something better than the usual blocks for inclining my drawing board with, I hit upon the following good scheme: I cut out two triangular blocks *b* of hard wood about 1 inch thick, drilled a hole in each, and slipped them on the ends of a wrought-iron rod a trifle shorter than the length of my board, as shown in the enclosed sketch. By leaving one of the blocks free to rotate on the end



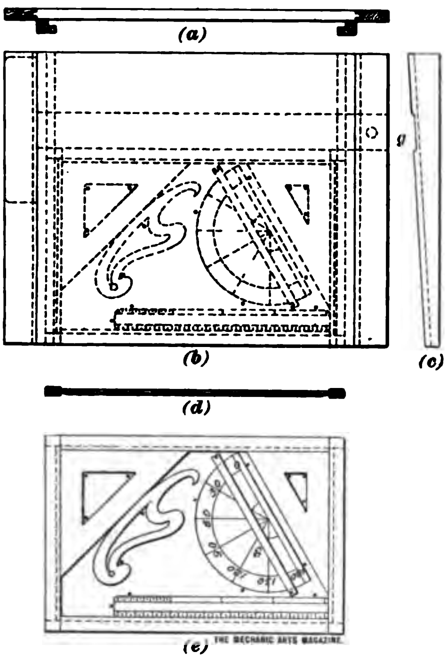
of the rod, the device becomes self-adjusting, and accommodates itself to any twist in the surface of the board or table, and, by making the sides of the blocks of different lengths, the inclination of the board can be varied at will. The sides of the blocks that I use are $4\frac{1}{4}$ inches, $5\frac{1}{8}$ inches, and $5\frac{5}{8}$ inches, respectively. By cutting off the corners as at *a*, the blocks are prevented from marking the board, but by leaving the edges of the corner surfaces sharp, the board is prevented from slipping.

A DRAWING-BOARD OUTFIT.

O. F. Paul Spitzel, Orange, N. J.

When I got my drawing-board, etc., at the commencement of my studies with The International Correspondence Schools, I was at a loss to know how to keep everything together properly, until I invented the scheme illustrated herewith. At (*a*) is shown the front of the drawing board, at (*b*) a plan, and at (*c*) an end view. I first cut

out a groove in each runner, as at g in Fig. (c); this takes the blade of the **T** square as shown; then I made a tray drawer, as shown at (d) and (e), to slide in under the board and to butt up against the blade of the **T** square. In this tray I pack away two triangles, a curve, a protractor, and a 12-inch



scale; s is a piece of clock spring, slotted at the ends so as to fit under the heads of two drawing pins, and thus keep the protractor flat on the bottom of the tray.

IMPROMPTU JAR FOR BATTERY.

Reader.

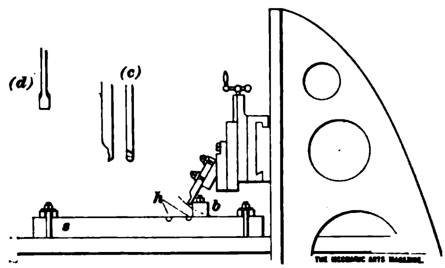
SOME TIME ago I had the misfortune to break the glass jar belonging to the battery that rings the house bell. Happening to look around, I saw an empty glass bottle almost the exact diameter of the broken jar, and I made up my mind to cut the neck off the bottle and so

save the cost of a new jar. To do this, and not having a diamond or other form of glass cutter, I tied a piece of copper wire around the bottle at the place where I wanted to cut it, and started the cut with a file; then I slowly ran a red-hot poker around the bottle, using the wire as a guide, as shown in the drawing. This cut the neck off perfectly clean, and gave me a suitable jar at the cost of but a few minutes' labor.

PLANING SHORT KEYWAYS.

Geo. F. Meyer, Milwaukee, Wis.

IN THE COURSE of shop work it is sometimes necessary to cut a keyway the length of which is less than the shortest possible stroke of the planer on which the job must be done. The sketch below shows how, with very little trouble, this may be done. The shaft s is first drilled for the ends of the keyway, with holes h, as usual; it is then clamped to the planer platen, and a block b



is clamped on top of the shaft, a little back of one of the end holes h; this block must be high enough to prevent the tool from getting over the top of it, the necessary height depending on the amount of travel of the platen. With this arrangement, during the return of the platen, the cutting tool is tilted up away from the shaft and starts to cut only when block b allows it to fall back into position at the commencement of the keyway. The holes h are, of course, of a diameter equal to the width of the keyway, and are drilled to the required depth with the usual tit drill. It is always best to plane a flat on the top of the shaft; this can be done by means of the cross-feed, using a tool like that shown at (d). A good form of keyway cutting tool is shown at (c).

ATTACHMENT FOR STEEL SCALES.

Anonymous.

WHEN I started in at the drafting board, some years ago, I made up my mind that the best kind of scale was one made of steel. The advantages of a steel scale over a wooden

one are that it does not shrink or warp, and that the graduation lines have a distinct depth. But I soon found that the steel scale has two serious disadvantages: It is difficult to pick up (being slippery and the ridge for handling being small) and the graduation lines and figures are in some lights very difficult to see. To overcome these difficulties, I fitted mine up in the manner shown in the accompanying sketches. Fig. 1 is an end view, just about full size; in it the shape and proportions of the scale itself are clearly shown. The attachment consists of a strip *a* of hard wood, the same length as the scale, and grooved on the under side so as to slide on to the ridge as shown. To the under edges of this wooden "back," as I call it, are attached on each side four strips *b* of stiff white paper, each a shade under 3 inches long. The completed affair is shown in Fig. 2. The figures are written on the white paper in India ink, and the paper is then coated with clear white shellac. On my scale, which, by the way, I have used for 8 years and is still in excellent condition, I graduated and figured the paper for full-size, half-size, quarter, and eighth. The figures are perfectly clear, and stand out in great shape as compared with those on the steel, and the wooden back makes the scale as convenient and easy to pick up and handle as an all-wooden one. I should add that the reason the paper strips are made in sections 3 inches long is that I found by experiment that if a single strip the full length of the scale is used, it will buckle up in damp weather, and shrink so much in dry weather as to pull itself off the wooden back. When made in 3-inch lengths, the paper strips always lie flat; the fact that mine have stayed on for 8 years is proof that they are secure.

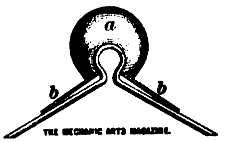


FIG. 1.

FIG. 2.

TWO MORE SECTION LINERS.

The two devices illustrated here are the best of numerous section-lining schemes sent in during the past month as contributions to these columns. There is nothing new about them or about any others received, but they will suffice to bring to a close the little controversy that Mr. Palmedo's article on patent-office drafting has caused. By this we mean that no other section liners will be illustrated or described here; there are many good ones on the market, and those draftsmen who wish the mechanical aid that they afford cannot do better than make a careful choice.

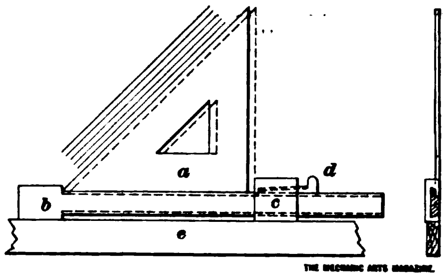


FIG. 1.

In Fig. 1 is represented a device that comes from Mr. Edward C. Fisher, of Huntington, W. Va. It is claimed that it is an improvement on the one contributed by Harry Bible, illustrated on page 129 of the April number of this magazine. Personally, we consider it inferior, for the reason that there are *three* pieces instead of *one*, and because if piece *c* were accidentally loosened, it would be difficult to set it to exactly the same spacing again. We would rather have two or three of the simple non-adjustable kind, and thus get all the variety of spacings desirable, than one of this construction and be continually having trouble with the setting. On general principles, too, a device consisting of one

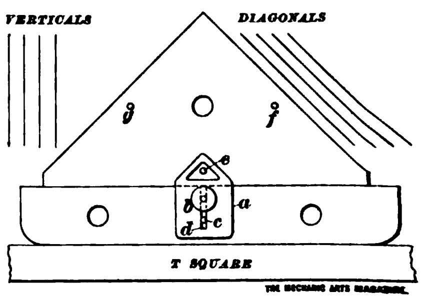


FIG. 2.

simple piece is better than a device for the same purpose made of three pieces.

The scheme shown in Fig. 2 was sent in by Mr. William Pittman, of Jerseyville, Ill. Though this, if nicely made, would doubtless do good work, it would be decidedly expensive to make, and if we mistake not there is something very similar on the market. The fact that it is possible to set it for vertical lines is of little or no importance, there being practically no such section lining done. It also consists of too many parts.—[Ed.]

HOW TO TAKE A DOUBLE PHOTOGRAPH.

S. J. Routledge, Pratt City, Ala.

Directions for obtaining a double photograph such as that reproduced here may

Fig. 1. A Double Photograph.

be of interest to some of the amateur photographers that read The Mechanic Arts Magazine.

Have the tinsmith make a cap to fit tightly over the hood of the lens, and have barely half of the bottom of the cap cut out, as shown in Fig. 2. Paint the inside of this cap black. To make a double picture, focus for the desired view as usual, having the subjects you wish to appear twice in the same picture well to one side of the center line of the picture as it appears on the ground glass; put on the half cap with the diameter vertical; draw the slide of the plateholder and expose; this exposure photographs the subjects and the half of the background that is behind them. Without moving or in any way disturbing the camera, have the subjects cross over to the other side and make a second exposure.

Fig. 2.

On developing, it will be found that the two exposures of the background have blended so perfectly about the vertical center line that the picture seems to have been taken with but a single exposure, while the subjects appear on both sides of the picture. In the photograph reproduced here we have the same boys sitting on both ends of the bench at one and the same time.

TO PUT UP A SHELF.

Otis, Cleveland, Ohio.

As a dabbler in photography, I had occasion the other day to put up a small shelf in the corner of my dark room. I had the shelf, but no brackets or other means of supporting it or securing it in place. Finally, I hit on the scheme shown in the illustrations herewith, using, in conjunction with three wire nails, three staples such as are employed for fastening telephone wire to a wall. Holding the shelf in position, I marked off for the nails and drove them in as shown, then secured the shelf by driving in the wire staples, one around each nail close up to the head. By this method neither the shelf

nor the wall is at all disfigured; and the shelf is very secure, yet can be taken down easily and without disfiguring the wall.

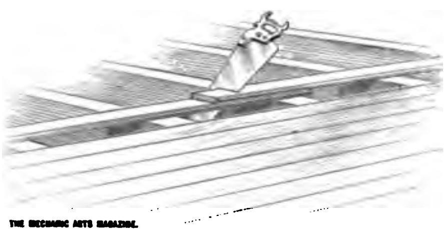
SAWING FLOORING.

C. Francis Jenkins.

When I went to serve an apprenticeship as a carpenter, one of the things I learned was to lay flooring. This isn't remarkable, for every boy would be taught that, but I noticed that breaking joints required considerable skill and dexterity in order that the

joints might not be conspicuous by gaping cracks. As usually done, the flooring is marked with a knife blade along the blade of a try-square very carefully held in place. The sawing is done with a fine saw (backed, frequently), and when these three—the knife, the square, and the saw—are used skilfully, and the flooring is run straight, and sawed under, a very fair joint is the result. It is not a rapid method, by any means, and it takes a good carpenter to keep out of the way of but one man laying and blind nailing.

Being, by nature, partial to "short cuts," which, translated, should mean the quickest way to do a thing well, I surprised my "boss" one Monday morning by offering to work the week out without pay if I could not saw flooring, making good joints, as fast as two men could nail it down, and as a side remark said I would use no scratch to work by. I had practiced in secret and knew I could do it. As the floor we were laying



was not a too particular job, he jokingly told "John" to "give the boy a chance to try." But I did it, much to their surprise, for I more than kept out of the way of both the boss's helpers. And this is how it was done:

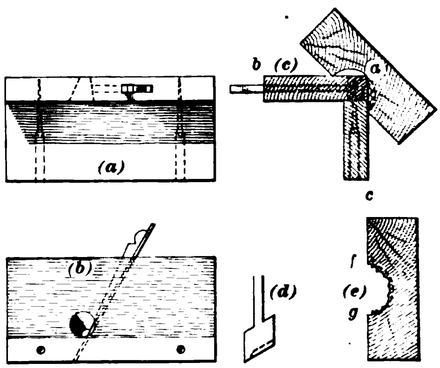
Two pieces of flooring were laid along parallel to that already nailed down, one piece overlapping the end of the other on a joist. Grasping both pieces of flooring with my left hand, the thumb at the point where I wanted to make the joint, I pulled the two pieces into position, with the joint a little past the joist, and *sawed through both at the same time*, using an eight- or nine-tooth saw. Of a consequence, when one piece was laid and the other butted up against it, the joint was all that could be desired. And the rapidity with which flooring can be laid by this method is a revelation to one accustomed only to the old method of knife joints.

The finest flooring can be sawed in this manner successfully, as also, with a little care, molding and other small stuff, following the same general plan of sawing through the two pieces at the same time while they are held in practically the positions they will finally occupy. The ugly slants in circular stair frames, in hip roofs, and the like can also be successfully managed in this way, and with great expedition. It is a good scheme, well worth adopting, and will be found to save not only time, but temper and material. It is the pleasure a man feels in using little schemes like this that makes his work worth doing.

A CORE-BOX PLANER.

W. A. Clough, Carthage, N. Y.

I WILL TRY to help out some of my brother patternmakers by describing a core-box planer that I have found of great assistance. Take an 8-inch "rabbet" plane and screw on to it, in the manner shown at (*a*) and (*b*), a 1-inch board of hard wood, making the width 1 inch less than the height of the



plane, so that the distance *a c* is equal to *a b*, and see that the angle *b a c* is exactly a right angle. Grind the planer blade to the dotted shape, as at (*d*), and so that the cutting edge is about ¼ inch wide. Mark out the semicircle for the core as shown at (*e*), and gouge out roughly in the usual manner; then trim the edges *f* and *g* to finish line, just far enough to give the plane a start, and do the rest with the planer. By this means a perfect semicircle is obtained without any difficulty, and much time is saved.

SUBSTITUTE FOR THUMBTACKS.

IF, INSTEAD of using thumbtacks, draftsmen would fasten paper to board with small copper tacks, they would be relieved of the annoyance of having T square and triangles constantly bumping up against the projecting heads. This scheme is better than it looks.

TRADE NOTES

IMPROVEMENTS IN BICYCLES.

THE ILLUSTRATIONS on this page represent some of the most striking improvements that have been made in the 1899 model of the Cleveland bicycle, manufactured by H. A. Lozier & Co., of Cleveland, Ohio. As enumerated in the makers' catalogue, the radical novelties include the Burwell combination ball-and-roller bearing; an entirely new method of anchoring the spokes in the hubs; a modified handle bar; bearings with lessened friction; modifications in the front and the rear forks; an improved crank-yoke; heavier tubing; fuller frame and fork reinforcements; a larger frame head; and refinements on the hollow axles.

FIG. 1.

Perhaps the most noteworthy of these improvements is the ball-and-roller bearing; this is shown in Fig. 1, and deserves to be thoroughly understood, because the average cyclist has come to believe something that is not true, namely, that in the ordinary ball bearing there is no sliding friction, and that, therefore, it is quite impossible to improve upon it. Now, when the balls in an ordinary bearing move as they do, all in one direction, it must be remembered that, as related to one another, the rear surface of every ball is moving in an opposite direction to the front surface of the ball behind it, and that there is a resultant of just so much sliding friction, due to this rubbing of the balls against one another. To help the reader to fully appreciate the significance of this, we show, in Fig. 2, part of a bowling-alley ball-way, down which the balls are returned to the bowlers. It is easy enough for one of these balls to roll down hill by itself, but things go much less merrily when several of the balls come in contact. Of the three shown touching, it will be seen that the middle one has two other balls to rub and grind against, the result being that these three soon come to a standstill, while the loose ball shoots ahead and races for home. In the Burwell ball-and-roller bearing there is a polished steel roller between each pair of balls, so that the surface motion of ball and roller is continuous, the only sliding friction being that due to the very slow and slight rubbing of the tiny pins upon which the rollers are carried. So far as it is mechanically possible to make it, therefore, this bearing is frictionless. The gain in easy running is positive, and a bearing thus fitted will run equally well in either the vertical or the horizontal position, whereas in the ordinary ball bearing the hub spins longer when vertical, because in that position the balls are wider apart and less subject to friction. But the ball-and-roller bearing possesses incidental advantages that do not at once reveal themselves. One of the annoying features of bicycle bearings is the constant rattling noise caused by the balls as they rise over the crest of the cone and drop with a ceaseless clatter one on top of the other; now, while this is going on, the other balls are bunched in close company underneath, and for a moment of time have to bear more than their share of the pedal pressure, involving friction and loss of power.

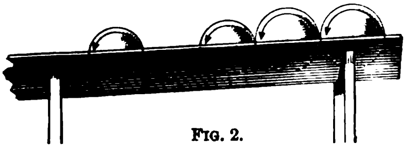


FIG. 2.

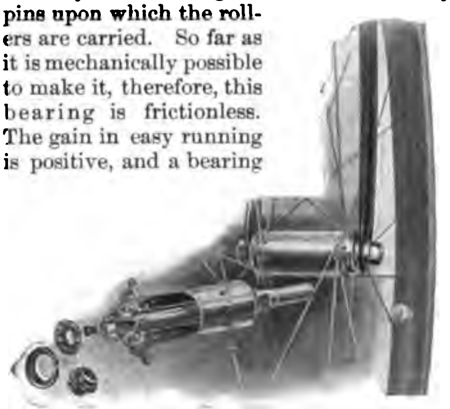


FIG. 3.

In the ball-and-roller bearing, not only is the disagreeable rattle stopped, but the pressure is evenly distributed around the cone.

Next in importance is the new direct spoke, illustrated in Fig. 3. The hub end of each spoke terminates in a compressed-steel ball about ¼ inch in diameter, and the hub is drilled to receive the spokes direct. There is an extension on one side of the spoke ball that makes it impossible for the spoke to turn or to come out, except when brought vertical to the hub; in the latter position it is at once removable. To provide for this improvement the hubs are made slightly larger than before, thus gaining in strength and making the general appearance more handsome.

BOOKS AND CATALOGUES.

Liquid Air and the Liquefaction of Gases—Theory, History, Biography, Practical Applications, Manufacture. By T. O'Connor Sloane, Ph. D. Published by Norman W. Henley & Co., New York. Price, $2.50.

The general interest that has been stirred up by accounts in the daily press, as well as in various magazines, of the wonderful achievements by Mr. Chas. E. Tripler in liquefying air, and generally vague statements with regard to the possible applications of liquid air in the industrial world, makes the appearance of the book before us most opportune. The book is written for the layman, and therefore necessarily reaches back to fundamental laws of physics and chemistry in preparing the reader for the understanding of the theory of the liquefaction of gases, and air in particular. These preparatory chapters fill nearly one-third of the book, and are as clearly and concisely written as is possible, perhaps, in treating such a subject; naturally they are not, and are not meant to be, very exhaustive, and reading them may be likened to a post-haste journey through a vast country, with a guide by your side, directing attention to the most important points. The journey is delightful; in other words, the subject is presented in by no means a dry manner, and affords pleasant reading. The next chapter contains a historical account of the development in the art of liquefying gases, from the early experiments to the latest methods, and gives incidentally the biographies of Faraday, Gretel Carlletet, Wroblewski, Olszewski, Dewar, and Charles Tripler as the most eminent workers in the field. Clear descriptions of the Linde apparatus and the Hampson apparatus are given, while that employed by Tripler is not so liberally described, but left somewhat wrapped up in mystery so far as the "liquefier" and the "valve" are concerned. This is to be regretted, as nothing is more conducive to disappointment to a reader seeking information than "undivulged" details of apparatus. Chapter XVI is an enumeration and illustrated description of the various startling experiments made by Mr. Tripler, and already familiar to many through the magazines. The closing portion of the book treats on some of the applications of liquid air, and here the reader is again somewhat disappointed, as he neither finds refuted nor sustained the sanguine statements that have now and then been made as to the possible use of liquid air in the industries. The author closes in saying that liquid air would present an ideal substance for the production of energy, *if only it could be produced cheaply enough.* And there's the rub. Let us hope that it will be.

The Pigeon Hole Library for Business Men.—A series of addresses and essays by prominent financiers, accountants, and business men. "Bookkeeping Frauds and Methods for Their Detection," "Partnership," and "Successful Methods in Business" are the titles of the first three numbers. The Business Publishing Co., 32 Lafayette Place, New York, N. Y.

NEW BOOKS OF INTEREST.

Any of which can be obtained from The Technical Supply Co., Scranton, Pa.

"Text Book of Sound." E. Catchpool. $1.40.

"Navigation and Nautical Astronomy." W. R. Martin. $6.00.

"Elements of Physical Chemistry." J. L. R. Morgan. $2.00.

"Text Book of Physics." Vol. II. J. H. Poynting. $3.00.

"Graphics." F. N. Willson. Part III, $1.50. Part V, $1.00.

"Cabinet-Making for Amateurs." J. P. Arkwright. $1.00.

"Beautiful and Quaint Designs in Leaden Glass; entitled: A book of sundry draughtes principally serving for glasiers, and not impertinent for plasterers and gardiners." $2.40.

"Photography." A. Brothers. $6.00.

"Metal Work." A. G. Compton. Part I, $1.50.

"Cupola Furnace." E. Kirk. $3.50.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

ERRATUM.—May, 1899, Answers to Inquiries, No. 98, answer to (*b*) should read: If you substitute for the 33-tooth a 50-tooth gear, you will decrease this distance in the proportion of 50 to 33, and the distance that a point on the drum will travel during one revolution of the 100-tooth gear will be $\frac{.758 \times 33}{50} = \frac{1}{2}$ inch.

***

(116) What is the latest method of etching a copper plate from which to print visiting cards, cards for wedding invitations, and similar work? How are the letters placed upon the plate before being etched, how is the surface of the copper prepared, and what is the acid used for etching? Explain also the process of printing from such a plate.

A. M. P., Brooklyn, N. Y.

ANS.—The plate for plate printing (whether of steel or copper) is not etched, but engraved by hand, in which operation great skill is required. For a visiting card the name is first written on the polished surface of the copper with a pointed steel pencil; this writing is done freehand. Then, with an engraving tool, the letters are cut into the copper. The process of printing from engraved plates is fully described in HOME STUDY MAGAZINE, June, 1898, Answers to Inquiries, No. 240. The making of cuts for illustrating purposes is fully described in the present number, in answer to question No. 122. The acid used for etching these cuts is nitric acid. The ink used for printing from copperplates is lithographic ink.

***

(117) (*a*) What is the weight of a cubic foot of hard wood, and what of a cubic foot of steel? (*b*) Do I run any risk in employing two separate attorneys when applying for a United States patent?

V. D. T., Cornwall, Ont.

ANS.—(*a*) Hard woods vary considerably in weight; the average weight in pounds of a cubic foot of dry ash is 38; cherry, 42; ebony, 76; elm, 35; hickory, 53; lignum vitæ, 83; oak, 59; sycamore, 37; walnut, 38. Green timber usually weighs from one-fifth to one-half more than dry. The average weight of a cubic foot of steel is 490 pounds. (*b*) You cannot make two applications for the same patent at the same time. As far as getting advice is concerned, you may go to as many attorneys as you like; there is no risk whatever; patent attorneys may be trusted.

***

(118) (*a*) What is the best shape for a small greenhouse? (*b*) Is it necessary for a greenhouse to be glazed with double glass? (*c*) What is the best way to heat such a house—by hot air, hot water, or steam?

W. E. W., St. John, N. B.

ANS.—(*a*) The proper construction of small greenhouses can best be ascertained by writing to The Lord and Burnham Co., Irvington-on-the-Hudson, N. Y. Ask them to send you their catalogue entitled, "Greenhouses for Amateurs." (*b*) It is not necessary to have double glass, providing your heating plant is large enough to supply enough heat during the coldest weather. (*c*) Heat by hot water and use 4-inch cast-iron pipes.

***

(119) (*a*) What is the construction and principle of action of the "Which Way" pocket level advertised in THE MECHANIC ARTS MAGAZINE? (*b*) Give diagrams showing the principle of the steam separator and the steam loop. (*c*) Can a soldering iron be made of any piece of copper by simply tinning it, or does the copper have to go through some special process? (*d*) Is it a good plan, after putting fuel into a furnace, to shut the chimney damper; will it, to a certain extent, stop the cold air from rushing in?

J. D. S., California.

ANS.—(*a*) A description of the "Which Way" level appeared in the "Trade Notes" department of the April number. (*b*) The water held in mechanical suspension in wet steam being heavier, volume for volume, than the steam, it follows that, if the direction of flow of the wet steam be abruptly changed, the particles of water, by reason of their inertia, will continue in the original direction of the current, while the steam passes off in another direction. This principle is made use of in steam separators, like the one shown in Fig. 1. The steam enters at *c*, and is deflected by a curved partition, which gives it a spiral motion about the pipe *a*. The particles of water are thrown against the walls of the vessel, and run down to the bottom of the chamber, while the dry steam passes up through the pipe *a* and discharges at the outlet *d*. The separator is provided with a drip pipe *h* and gauge glass *g*. The four wings *b* destroy the spiral motion of the current of steam, and offer additional surfaces for the particles of water to adhere to. The steam loop is an appliance for automatically returning the water of condensation from a steam pipe or separator to the boiler. Its arrangement is shown in Fig. 2, where *a* is the boiler, *b* the steam pipe to the separator, and *k*

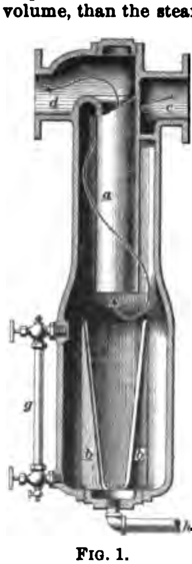


FIG. 1.

the steam pipe leading to the engine. The operation of the loop is as follows: Any water that has collected in the bottom of the separator c is forced up the riser d and through the horizontal pipe e into the drop leg f. Then, as soon as the sum of the steam pressure in the drop leg and the pressure due to the head m of water between $g\,g$ and $h\,h$ exceeds the boiler pressure, the check-valve l opens, and some of the water in the drop leg enters the boiler. The check-valve closes as soon as the boiler pressure

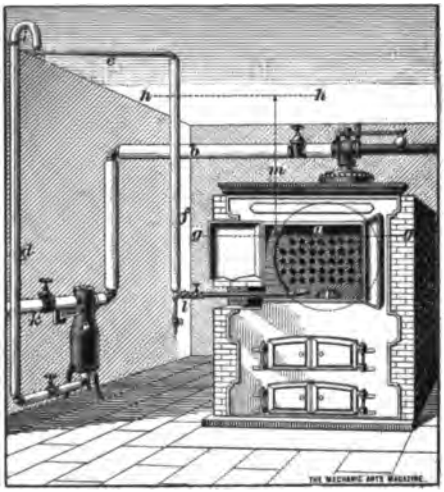


FIG. 2.

exceeds that in the drop leg; it opens again as soon as the pressure in the drop leg exceeds the boiler pressure. The loop at i prevents any water in the horizontal pipe e from flowing back into the separator. (c) Any piece of copper or brass can be used for a soldering iron, copper being preferable. (d) If you do not want a freshly coaled fire to burn up, the damper may be closed. This certainly prevents the entrance of air to the furnace.

* * *

(120) I would be pleased to have you recommend a clear and concise treatise on electric generators and motors, a book giving complete information concerning the construction, peculiarities, and care of same, together with the class of work to which each is adapted. I also want a good work on steam and water piping for large plants. F. P. K., Erie, Pa.

ANS.—The most suitable book treating on dynamos and motors is probably "Dynamo-Electric Machinery," by S. P. Thompson, price $4.75. This does not treat very fully of alternating-current work, but you could obtain such information in this line from the same author's "Polyphase Electric Currents," price $3.50. There is no work on piping that we can recommend, but you will find some interesting and instructive articles on the subject in recent numbers of "Power" and "The American Machinist." The above books are for sale by The Technical Supply Co., Scranton, Pa.

* * *

(121) (a) I have a Laidlaw-Dunn-Gordon duplex boiler feed-pump, each piston of which makes about 15 strokes per minute. One piston travels too far at one end, pushing the joint of the steam ring over the counterbore of the cylinder; this allows steam to blow through the joint and out at the exhaust, and thus causes the piston to stick at this end. It hangs worse when running slow or when steam is rising than at other times. I have tried shortening valve stem so as to make it take steam earlier, but this has no effect; but by setting up the gland at the stuffing-box, and thus increasing the friction at that side, the stroke is shortened and the trouble ceases, but, of course, it begins again in a short time. Please give remedy. (b) Will a bad wabble in a flywheel (not a bandwheel) 11 feet in diameter, and making 105 revolutions a minute, cause the engine to pound? F. M. E., Gainsville, Texas.

ANS.—(a) The cause of the trouble appears to be that there is too little compression, due probably to leakage of steam from the compression space after the piston covers the exhaust passage. The leak may be between the valve and its seat, or around the piston ring—probably the latter. The remedy is to provide sufficient compression by stopping the leak. In some pumps the compression is controlled by valves, which regulate the amount of opening of a connection between the steam and exhaust passages; if your pump is provided with this attachment, the compression can be increased by closing the valve so as to reduce the quantity of steam that escapes from the compression space. (b) An unbalanced flywheel is very likely to cause the engine to pound; in any case, it will cause extra stresses in the shaft and wear on the bearings.

* * *

(122) (a) Please explain fully the process by which cuts similar to those used in THE MECHANIC ARTS MAGAZINE are made. (b) How are calling cards printed from a copperplate engraving, the letters being sunk in the plate? I do not understand how the ink is applied. (c) What kind of steel is used in the manufacture of steel magnets, and how is the steel hardened? G. C. B., La Crosse, Wis.

ANS.—(a) The first step is to make the drawing from the sketch supplied to the illustrator. The drawing is generally made about twice as large as the cut is intended to be when printed. This is done to get sharper lines. On the drawing, as handed to the engraver, is marked the reduction that is to be made. If the cut is required to be half the size of the drawing, the latter is marked "reduce ½." Other reductions are generally given in figures, thus, "reduce to 3¼ inches." A reduction of course affects both the length and the width. Thus, if a drawing 9 in. × 6 in. were marked "reduce ½," the cut would be 4½ in. × 3 in. The engraver takes a photograph of the drawing, reduced to the required size. A print is then taken from the negative on a sensitized zinc plate. The next process is to etch this plate with acid. Where the dark lines occur on the plate (corresponding to the lines on the drawing), the acid cannot attack the plate. The result is that the plate is eaten away wherever a white space shows on the drawing, and is left unmarked wherever ink lines occur. Next, the plate, or "cut," is routed where large spaces occur, being cut down about $\frac{1}{16}$ of an inch below where the acid has eaten. This insures that if, in printing, the paper bulges somewhat inside these spaces, it will clear the plate. Close up to the lines, the plate is allowed to remain just as the acid left it—that is, there is no routing done nearer than within about $\frac{1}{16}$ of an inch of the lines. It is now, together with a proof taken from it, given to the engraver to "trim up," he being also provided with the original drawing as a guide. He removes any imperfections that may now appear in the plate, the proof before him serving to guide him in finding these bad spots. The cut is then "blocked," that is, tacked down on a smooth, level piece of hard wood, of such a thickness that the height from the under side of the wood to the top surface of the plate is just equal to the depth of type used in the accompanying text. In technical language, the plate is made "type high." (b) A strong ink is used for this purpose,

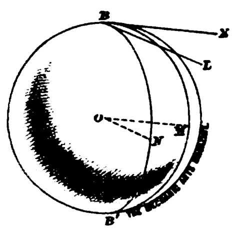
applied to the plate by means of a *ball*, as it is called by printers. This is a spherical instrument, made of sheepskin and stuffed with wool or hair. This is coated with ink and the latter thus rubbed well into the lines of the plate. A card is then laid on the plate and the two passed between rollers, under a heavy pressure. The ball is used to ink the plate again after every imprint. (*c*) Various fancy steels, such as tungsten, etc., are often spoken of in this connection, but in the majority of cases a cheap, low-grade steel, costing from 2½ to 4½ cents a pound, wholesale, is employed, and is quite suitable. It is hardened by heating to a bright cherry red and cooling right out in cold water. It is magnetized by stroking it across the poles of a powerful electromagnet.

***

(123) I want a simple rule or rules for finding the area of any part of the surface of a sphere, so as to get the size of blank required to make it.

W. L. B., Meriden, Conn.

ANS.—Every plane section of a sphere is a circle; a section made by a plane passing through the center of the sphere is called a *great circle*. A *spherical lune* is a portion of the surface of a sphere bounded by two semicircumferences of great circles. A *spherical polygon* is a portion of the surface bounded by three or more arcs of great circles; a spherical polygon bounded by three sides is called a *spherical triangle*. The *angles* of a spherical figure are the angles between the arcs of great circles which bound the figure. A spherical angle is measured by the angle between the planes of the great circles containing the angle, or by the angle between two tangents, one drawn to each of the circles at their point of intersection; thus, the spherical angle MBN is measured by either of the equal angles KBL or MON. The angle $MB'N$ is also measured by MON, and therefore the angles MBN and $MB'N$ of the lune $MBNB'$ are equal.



Let R = radius of the sphere;

A = area of the surface of sphere;

π = ratio of a circumference to its diameter;

L = area of a lune whose angle contains B degrees;

T = area of a triangle the sum of whose angles contains S degrees;

P = area of a polygon of n sides the sum of whose angles contains S degrees.

The following formulas are proved in books on geometry:

$$\pi = 3.1416 \text{ (approximately)} \qquad (1)$$

$$A = 4\pi R^2 \qquad (2)$$

$$L = \frac{\pi R^2 B}{90} \qquad (3)$$

$$T = \pi R^2 \frac{(S-180)}{180} \qquad (4)$$

$$P = \frac{\pi R^2 [S-(n-2)180]}{180} \qquad (5)$$

The area of any portion of the surface of a sphere bounded by arcs of great circles can be found by these formulas.

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(124) (*a*) Is there any difference between a freight-car triple valve and a passenger-car triple valve? (*b*) Are they all "standard"? If so, why are some marked F and others P? (*c*) What is the origin of the expression "a stuck wedge"? Seeing that the wedge remains stationary and that it is the driving box that moves, would it not be more correct to say "a stuck box"? (*d*) Explain how, on an 8-wheeler, a stuck box is detected, and give the remedy therefor. (*e*) Why is it that, in running the 8-wheeler and putting the reverse lever three notches back of center, it continues to run forward, and yet is as square as if notched up four notches and in back motion? (*f*) Standing still, if the engine is hooked up two notches and given steam, it won't move. Why is this? (*g*) What is the coal capacity of a pit 8 feet 5 inches long, 4 feet 8 inches wide, 3 feet 1 inch deep? Show the working of this problem.

R. F., New Orleans, La.

ANS.—(*a* and *b*) Yes; the size of the ports is not the same in each case. As the triples have the same outward appearance, it is necessary to distinguish between them in some way; hence the use of P to denote passenger and F to denote freight. (*c*) The point you raise is an amusing one; you are certainly at liberty to talk of "a stuck box" if you prefer it, as, also, you are to talk of a hot journal instead of a hot box, or a hot crosshead gib instead of a hot guide. When the contingency in question does occur, the part we have to *move* is the wedge, in order to free the box. It seems rational, then, to talk of a "stuck wedge." You say that the *box* moves; we prefer to regard the frames (and, therefore, the shoes and wedge) as moving. True, when a high or a low spot in the track is struck, the wheel (and box) moves momentarily in space; or, in other words, relatively to the normal rail level and therefore to the frames of the engine; but when running along an ordinary level track the box is at rest relative to the rail, while the frames, due to the engine rocking on her springs, move up and down. So that, speaking generally, we may say the wedge moves up and down on the side of the box. Of course, the point is not of the least importance—nothing but a verbal quibble. (*d*) The sticking of a wedge is readily discovered by the "riding" of the engine, the spring of that particular wheel being then inoperative. Even if not actually stuck fast in the jaw, there being still a little vertical motion, the engineer can tell by the loss of freedom in the engine's riding that something is not quite right. The engineer is sometimes warned of a stuck wedge by finding a hot journal, which is usually the cause of the trouble. To remedy it, slack the upper nut of the wedge bolt and tighten up the lower one (the one underneath the frame clamp) and at the same time get some one to jar the pedestal by hammering. You can get a bar on to it from the outside, a third party hammering on the bar with a large hammer or anything available. It is better, however, to use a small hammer directly on the frame itself, as by this method a better effect can be produced. If the wedge won't move, put a crowbar underneath the frame and "lever" on the top of the wedge, the pedestal legs being jarred as before. At the outset, put some turpentine or naphtha down between the stuck surfaces. Either is very searching stuff; if neither is at hand, use kerosene from the air-pump supply. If the engine has two shoes and a wedge, it will be more difficult to get at the latter from the top, as the shoe will be in the way, reaching, as it does, to the top of the pedestal jaw, and the wedge being pretty thin at the top. You can work directly on its top, however, with a bar bent a little at the end and narrow enough to go down between the shoe and pedestal. If you find you can't move things, give the surfaces a good dosing with kerosene, as just mentioned, and then run the wheel up over a piece of iron or hard wood from 1 inch to 2 inches thick; the sudden drop of the frames as the engine passes over this will in most cases separate the parts. (*e*) If the engine has been out of the shops for a very long time, there will be a lot of play everywhere—

reach-rod, link-hanger, and saddle pins, to say nothing of the reverse-lever catch and sector teeth (when not tapered), albeit small in amount. All this throws the engine more into full gear, so that when in the third notch from the center in the back gear, she is nearer mid gear than appears to be the case. If, in addition, she has been set about an eighth blind in full gear, the mid-gear port opening will be so small that although the steam is working adversely to the engine (albeit reduced in degree, as shown above), the amount may be such as not to appear to check the engine's speed much. But the fact is still there that the engine *is* taking steam against herself and will eventually check up. (*f*) From what we infer as to the pitch of notches, when you pull her up two notches, that is, into the third notch from the corner, she will be cutting off at about 15 inches, if a 24-inch stroke. In this position, if the main rod is 7 feet long, one of the cranks will be about $10\frac{1}{4}°$ past the quarter. So if she has stopped in this position, the above-mentioned crank will get no steam when the throttle is opened, and the other crank being only $10\frac{1}{4}°$ off dead center, is in an unfavorable position to make much use of its steam, the main rod being too much in line with piston rod. If one crank is on the quarter, it will be in a pretty favorable position for turning the wheel, but the port opening is nearly closed. The other crank, being on the center, does not count at all. Then, again, one of the cranks may have stopped such an amount past the dead center as to be at right angles to its main rod, and therefore in a most favorable position for turning; in our case, the angle will be $81\frac{3}{4}°$ or $8\frac{1}{4}°$ from the quarter; here there will be more port opening, but the other crank will be doing nothing—in fact, compression would be against her, if running. It all depends, in short, on the position the engine has stopped in. There will only be about three-fifths of the port open, anyway, notched up as she is; this, however, would suffice if the crank had stopped in a suitable position and there were very little weight behind the tender. If the engine were much worn, that would be in favor of her starting in the third notch, as the link would be nearer full gear than the lever indicated. (*g*) First, to find the capacity of the pit in cubic feet, multiply the three dimensions together. Thus, $8\frac{4}{12} \times 4\frac{5}{8} \times 3\frac{1}{12} = 121.1$, say 121, cubic feet. Now, to find the weight of coal the pit will contain, it is very evident one must know the size of the coal, as you can get more weight of lump coal in than you can of buckwheat, owing to its lying more "solid"—not so much air space. (And there are many intermediate sizes.) Then, again, the coal may be either anthracite or bituminous; the former is from 10 to 15 per cent. heavier than the latter. To find how many tons (of 2,240 pounds) there can be stowed in the above bin, bunker, pit, or whatever it is, divide 121 by one of the following numbers, according to the kind and size of coal:

Anthracite—Buckwheat, 44; egg, 43; lump, 39.
Bituminous—Small, 50; large, 45.

For example, if you are using lump anthracite, the pit will hold $\frac{121}{39} = 3\frac{1}{10}$ tons, about. If small bituminous, $\frac{121}{50} = 2\frac{2}{5}$ tons, about. Judging from the locality whence you write, you evidently use only bituminous coal; the information, however, regarding anthracite, may be found of interest.

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(125) Referring to your answer to question No. 89 in the April issue of THE MECHANIC ARTS MAGAZINE, I wish to say that a locomotive (assumed to be in a position to move forward) can start the greatest load when the crank is at the lowest position. There are two excellent reasons for this: *first*, the side of the piston head subjected to steam pressure is not reduced in effective area by the presence of a piston rod in the active end of the cylinder; *second*, the useful force tending to produce tractive effort at the rail is the horizontal component of the push or pull in the connecting-rod; the vertical component has the same character and value in both positions of the crank, and produces no other effect than to lessen the weight on the main driver axles by transferring some of the weight of the boiler and frame from the axle on to the crankpin. Now, it is easy to show that the greatest pressure between the axle journal and brass is induced when the crank is at its highest position, and therefore there is then the greatest frictional resistance to be overcome by the connecting-rod, and therefore so much less tractive force; similarly, there is the least frictional resistance when the crank is at its lowest position, and consequently there is then the greatest net tractive force. I have spoken to a number of locomotive engineers about this matter, and they all agree with me.

T. H. R., North Adams, Mass.

ANS.—While we acknowledge to some extent the justness of your criticism, it appears to us that the answer given fits the question asked exactly. Evidently the questioner had an idea that the difference

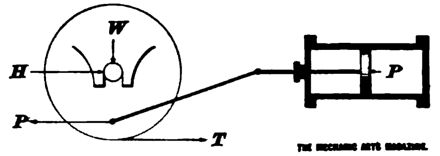

FIG. 1.

in the height of the crankpin from the rail in some way influences the tractive force, and the answer shows the well-known fact that, neglecting internal friction, etc., the tractive force is the same whether the crank is above or below. While it did not occur to us to take account of the points you mention, we should not in any case have deemed it expedient to include a refined discussion of these points in the answer. As to your contentions, we think you have altogether overestimated the importance of the two points you mention. We, of course, grant that the decreased area due to the piston rod lessens the pull when the crankpin is above the axle (although this criticism fails in the case of engines having a tailrod, i. e., extension of piston rod through front head). Let us, however, go a little more deeply into the question of friction. In Fig. 1, with the crankpin in its lowest position, it is evident that

$$P = T + H,$$

or,

$$H = P - T,$$

where H is the horizonal pressure between journal and frame; T is the tractive force; and P is the horizontal component of the connecting-rod thrust, and is equal, of course, to the total pressure on the piston. When the pin is above the center, we have the condition shown in Fig. 2. Here, $H = P + T$. In both cases, taking moments about the center of the journal,

$$T = \frac{r}{R} P.$$

Hence,

$$H = P\left(1 - \frac{r}{R}\right) \text{when pin is below.}$$

$$H = P\left(1 + \frac{r}{R}\right) \text{when pin is above.}$$

For a fair value of $\frac{r}{R}$, we may take .4; then, for pin below, $H = .6\ P$, and for pin above, $H = 1.4\ P$. We must, however, take into account the crank on the other side. In either case the opposite crank is on a center, and $H = P$. Now, let $W =$ the total load on

one journal-box. Combining the vertical force W with the horizontal forces P, $.6\ P$, and $1.4\ P$, we have as the three resultants:

$$F_1 = \sqrt{W^2 + P^2},$$
$$F_2 = \sqrt{W^2 + (.6\ P)^2},$$
$$F_3 = \sqrt{W^2 + (1.4\ P)^2}.$$

Suppose the cranks are as shown in Fig. 3; then the force on one journal is F_1, and that on the other is F_2.

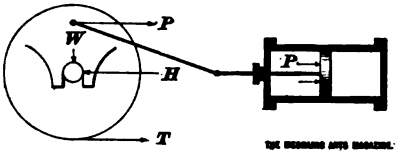

FIG. 2.

When the cranks are as shown in Fig. 4, the force on the one journal is F_1, and that on the other is F_3. The force W is always considerable, compared with the force P, so that, in practice, F_1, F_2, and F_3 are not very different. Besides the inequality of the forces on the two sides of the locomotive, the fact that frequently these forces are acting in opposite directions, as in Figs. 1 and 2, throws great doubt on the influence of this excess of F_3 over F_2 on the tractive force. If we wish to carry the refinement still further, we might take into account the rotating parts, etc. On the whole, we are inclined to think that the friction due to the excess of pressure on the journals will exert very little influence on the load that the engine can start. With a piston rod extending through the

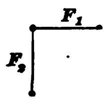

FIG. 3.

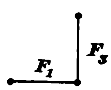

FIG. 4.

front end, we would as soon take chances with the crankpin above. We may add that, so far as our personal experience among runners goes, we have always found the opinion general that a better start can be made from the top than from the bottom quarter.

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(126) What is the greatest height above the surface of the water supply over which a siphon will draw water? H. M. B., San Francisco, Cal.

ANS.—At sea level, the greatest theoretical height is 34 feet—the height of a column of water that will be supported by the pressure of the atmosphere. At greater elevations, the atmospheric pressure, and, consequently, the theoretical height to which water can be raised, is less. Practically, it is generally difficult to operate a siphon over an elevation of more than from 20 to 24 feet, depending on the elevation above sea level and the size and length of the pipe.

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(127) (*a*) When a student of The International Correspondence Schools, Scranton, Pa., has completed the Complete Course of Architecture, he is presented with a diploma or certificate of proficiency. Is this as good as a license from a board of examiners of architects? (*b*) Is there a law in the state of Pennsylvania prohibiting an architect from practicing his profession unless he has a license or certificate from some technical institute? I. S., Osnaburg, Ohio.

ANS.—(*a*) The certificate or diploma from The International Correspondence Schools means that the student has passed with credit through a prescribed course of study. It represents work done, and is as much a credit to the holder as a certificate from a board of examiners. (*b*) There is no law in Pennsylvania requiring a practicing architect to have a license or diploma. Illinois is the only state having such a law.

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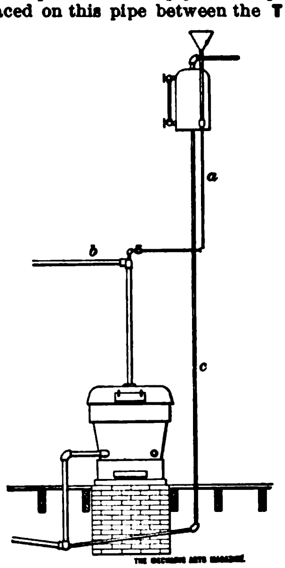
(128) (*a*) On a low-pressure hot-water heating system, to which pipe should the expansion pipe be connected, and why? (*b*) Referring to the enclosed sketch, *a* is a relief pipe taken from an overhead system of heating; are the connections shown correct? (*c*) In the same sketch, *b* is a pipe that feeds three radiators below it and one on the floor above. In connection with these radiators, is the method shown of running the pipes to the expansion tank the best? (*d*) If, instead of pipe *c*, as shown, connecting the expansion tank to the return pipe, the connection to the latter were made from below, by means of an elbow so as to form a sort of trap, would better results be obtained in any way, and would there be less tendency for the water to boil up in the expansion tank? (*e*) When making screwed joints in hot-water or steam pipes, I have always used a mixture of red lead, linseed oil, and salt; it has given fairly good results, but if you know of anything better, I shall be glad to have it. F. W. R., New London, Ohio.

ANS.—(*a*) The expansion tank should be connected to the top of the flow main as you show it. This will allow steam to escape into the tank, and thence to the atmosphere, if the boiler should generate steam. (*b*) The connections shown are correct, provided that the steam or air cannot blow out of the mouth of the funnel shown on the top of the relief pipe. A stopcock should be placed on this pipe between the T which enters the side of the expansion tank and the funnel. It is not necessary to place a vent-cock at the point where the relief pipe connects to the flow main; in fact, this cock should be taken out. It is best to have an open communication between the flow main and the expansion tank. (*c*) The method of running the expansion pipes as shown in the figure will not affect the heating of the radiators you mention. The arrangement is as good as any other arrangement. (*d*) No. A trap on the pipe *c* will not benefit the arrangement. If the pipe *a* is quite large, say 1 inch or 1¼ inches in diameter, it will prevent hot water from backing up in the expansion tank, by allowing steam to escape into the expansion tank, so that the boiler will remain charged with water, even when boiling furiously. (*e*) A mixture of good red lead and boiled linseed oil is about as good a cement as can be used on hot-water piping.



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(129) Will you kindly give a rule for adjusting the long-bubble tube beneath an engineer's transit, so that, when level, it will be parallel with the line of sight? The transit is to be used for leveling purposes. J. H. L., Lyonsville, Cal.

ANS.—Choosing a reasonably level piece of ground, drive two pegs A and B several hundred feet apart, and set up the instrument midway between them.

With the level on the telescope truly horizontal, read the rod held upon each peg. The difference of the readings will be the true difference of the elevations of the pegs, no matter how much the instrument may be out of adjustment. Then set the instrument over the peg A, and measure the height of the cross-wires above this peg. With the target set at this height, plus or minus the difference in the elevations of the pegs, according as the peg A is above or below the peg B, hold the rod on the peg B and direct the telescope so as to bring the cross-wires exactly upon the color lines of the target. In this position adjust the level tube so as to read truly horizontal. The operation is somewhat simplified by driving the pegs to exactly the same elevation. Also, instead of setting the instrument over one peg, it is generally more convenient to set it as near as it is practicable to read the rod held upon it, and use this reading of the rod for the height of the cross-wires above the peg. In order to insure accuracy, the entire operation should be repeated.

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(130) I am about to build an extension to my house, consisting of a kitchen 12 ft. × 14 ft., facing north, and I would like it as near frost-proof as possible, since the range and tank will be connected to the city water. I have thought of putting an inch or so of mineral wool at center of studding (which is 2 in. × 4 in. before plastering), leaving an air space on each side of the wool. The space above the rafters I intend to use for light storage. Would tar paper held up under the roof with strips be sufficient protection? Under the floor I thought of using tar paper with ship lap. Kindly advise me as to the best method of protection. D. M. L., Omaha, Neb.

ANS.—Tar paper and mineral wool, used as you suggest, would have a good effect in preventing the heat from escaping through the walls and roof. The great loss of heat, however, in an exposed position, such as your extension will occupy, will occur through and around the doors and windows, unless great care is taken to make them tight. The best plan for avoiding loss through the door is to build a small vestibule outside, thus having a double door and a dead-air space between. For the windows use heavy felt weather strips. Finally, be sure to arrange your boiler and range on the side of the extension next to the main house, thus taking advantage of heat radiating through this wall.

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(131) I want a good book on topography, one that treats specially on calculation; kindly give me the names of several works that you would recommend, mentioning the names of the authors, and the prices. O. B., Mexico.

ANS.—"The Topographer, His Instruments and Methods," by Haupt, has numerous maps, plates, and engravings; price, $3.00. "Topographical Drawing and Sketching," by Reed, includes the application of photography, and contains 24 large plates; price, $5.00. These books can be obtained of The Technical Supply Co., Scranton, Pa.

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(132) In the appendix to Hopkins' "Experimental Science," there is an illustration and explanation of an Edison phonograph motor. Kindly give the dimensions of this motor and the size of wire to be used; also, explain how to wind the armature for two brushes. Can this motor be made to run on 4 watts? E. A. A., Granite Falls, Minn.

ANS.—We refer you to the publishers of the book named, Munn & Co., New York, N. Y.

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(133) (a) Kindly give a recipe for blue ink for branding on wood. (b) Give the names, prices, etc. of any books that you can recommend on the designing of steel structures. I particularly want information on how to design and build a steel structure to carry a water tank, 20 feet in diameter and 20 feet deep, to be 60 feet above ground. If you can also tell me where I can obtain plans and specifications for this, and what the same are likely to cost me, I shall be much obliged. York, Ontario.

ANS.—(a) Boil borax and shellac in water till they are dissolved, and withdraw from the fire.

Shellac	2 oz.
Borax	2 oz.
Water	25 oz.
Gum arabic	2 oz.
Ultramarine	—

When the solution has become cold, add rest of 25 ounces of water and ultramarine enough to give the mixture suitable consistency. (b) "Theory and Practice of Modern Framed Structures," by Prof. J. B. Johnson and others, devotes a chapter to stand pipes and elevated tanks. This is probably the best book published on the designing of steel structures; price, $10.00. Considerable information can doubtless be obtained, also, from a book entitled "Stand-Pipe Accidents and Failures," by Prof. Wm. Pence; price, $1.00. Both books are for sale by The Technical Supply Co., Scranton, Pa. We know of no published specifications for elevated tanks; but general plans and considerable other information can doubtless be obtained by addressing any of the construction companies making a specialty of this work. The Chicago Bridge and Iron Company, Washington Heights, Chicago, Ill., have given considerable attention to this class of construction.

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(134) Kindly explain how piston packing rings are made. S. H. D., Franconia, N. H.

ANS.—You will find the information you require in HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., August and July numbers, 1897, in an article in two parts, entitled "Locomotive Piston Rings."

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(135) (a) What is the best treatise on the manufacture of brick? (b) I also want a good book on the construction of roads; can you tell me of one? L. L. G., Greenville, Miss.

ANS.—(a) "A Rudimentary Treatise on the Manufacture of Bricks and Tiles," by E. Dobson, is said to be a good work on this subject; price, $1.00. (b) "Highway Construction," by Austin T. Byrne; price, $5.00. Both books are for sale by The Technical Supply Co., Scranton, Pa.

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(136) (a) In what book or periodical can I obtain information as to the number of British thermal units (B. T. U.) of heat developed during the chemical union of various elements, together with a full description of the method of determination? For instance, the chemical combination of two of hydrogen with one of oxygen to form water; of one of carbon with two of oxygen to form carbon dioxide; of one of carbon with four of hydrogen to form marsh gas; and so on. (b) What is the method of determining the number of B. T. U. contained in any given quantity of fuel, such as a pound of coal, a gallon of oil, a cubic foot of coal gas, etc.? (c) Where can I obtain information regarding the Parsons and De Laval steam turbine? D. C. W., Johnstown, Pa.

ANS.—(a and b) "Physico-Chemical Methods," by Dr. J. Traube, translated by W. L. Hardin, $1.50; "The Calorific Power of Fuels," by Herman Poole. These books can be obtained of The Technical Supply Co., Scranton, Pa. (c) Articles have appeared from time to time in technical journals, particularly in "London Engineering." Probably the information can be obtained most directly from the manufacturers. Address C. A. Parsons & Co., Newcastle-on-Tyne, Eng. The De Laval steam turbine is manufactured in Stockholm, Sweden; the exact address of the company we do not know.

SELF HELP

AMBITION'S RIGHTFUL CALL.

LECKY, in his "History of European Morals," lays down the principle that "the most effectual method that has been devised for diverting men from vice is to give free scope to a higher ambition." This statement we find supplemented and emphasized by Henry Ward Beecher in his lectures to young men, to whom he says: "We must endeavor to inspire every calling in life with an honest ambition for intelligence."

The modern system of technical education, besides being of incalculable value to the workingman, renders inestimable aid to men not only in the engineering, but also in the ranks of the liberal professions as well: to the lawyer, the physician, the clergyman, the editor, and the litterateur. The successful man has one distinctive and noble characteristic: he is, in season and out of season, industrious. No man that expects success can afford to become an idler after he obtains his education. That time should mark the real beginning of a life of arduous study. The more a man advances in professional work, the more he finds he needs to know. In the very outset of the race of life, he will be distanced if he does not devote himself to earnest and systematic study. How many young men begin careers with highest promise, as journalists, jurists, physicians, civil engineers, surveyors, and the like, and yet, after a few years, drop into comparative oblivion. Examine their lives closely, and you will find that, at a certain period, they thought themselves independent of study's aid, and at once began to fall behind in the race. Instead of their taking heart and resuming courage, they lost resolution and fell by the wayside.

We must either advance or recede. There is no such thing as standstill in the road of success. If young men, just across the threshold of their professional careers, employed spare moments in self-improvement, failure would be in their lives an unknown quantity. The value of any possession is to be chiefly estimated by the relief that it can bring us in the time of our greatest need. In this respect, no possession can equal the habit of study, which, apart from the knowledge it assures us, secures discipline of mind and passion, evenness of temper and confidence in self—of truly inestimable value in the dark days that beset every human life. This habit must, to be either vigorous or useful, like virtue itself, of which it is an emanation and a manifestation, show itself regularly and constantly active, not breaking forth occasionally with a transient luster, like the blaze of a comet, but regular in its returns, like the light of day; not like the scented gale which sometimes feasts the sense, but like the ordinary breeze which purifies the air and renders it healthful.

When we reflect on the established truth that the happiness of every man depends more on the state of his own mind than on any one external circumstance, nay, more than on all external things put together, we may have just conception of the value of the habit of study. How many young persons at first set out in the world with excellent dispositions of heart, generous, charitable, and humane; kind to their friends, and amiable among all with whom they associate; and yet, how often do we not see all these fair appearances unhappily blasted in the progress of life, through the influence of idleness, which leaves an open door in the youthful heart to loose and corrupting pleasure; and these very persons, once a promise of blessing to the world, sink down, still in early life, to be the burden and nuisance of society. Happy is that young man who spends his time in making himself wise; who, as the will and understanding are the two ennobling faculties of the soul, thinks himself not complete till his understanding is equipped with the valuable furniture of knowledge, and his will strengthened by studious industry; who, when ambitious, is not to be admired for a false glare of science, but lives for the gentle and sober luster of unfailing wisdom and exact knowledge.

THE STORY OF PROF. BARNARD.

THE story of the career of Prof. Edward Emerson Barnard, the astronomer, is that of a poor boy, who acquired an interest in such work by reading a book which happened into his hands, and which resulted in the keen search for more information. Today he stands in the front rank of his profession.

Professor Barnard was born in Nashville, Tenn., on December 16, 1857, and his education was limited to two months' attendance at the common school besides such instruction as his mother could give him. Fatherless and destitute at the close of the war, he went to work in a photographic studio, continuing at that occupation until 1883. During that time he had mastered every department of the photographic art. Throughout his career his was a single-minded struggle for existence, as he was handicapped by poverty from the first, and compelled to fight the battle of life alone.

Early in life he became interested in optical matters, which interest was increased by the use of the lenses in the gallery where he worked. In 1876 he came into possession of a copy of Dr. Thomas' book on "Practical Astronomy," and it awakened a thirst for astronomical knowledge, which has never since ceased to be his controlling motive. This work, long since left behind in the great advance of science, was like a revelation. It told stories of the stars and the planets, and the wonder revealed by the telescope. Now, for the first time, he had some idea of the uses of astronomical instruments. He had never seen either a telescope or an observatory. All he knew of the literature of the subject was found in this old book. From the maps of the constellations and other engravings, he speedily learned to identify the objects in the sky about which he had been reading, and the descriptions of celestial wonders had now a new interest. Then came the desire to possess some kind of a telescope, and finally he obtained the object lens of a common spy glass, and mounted it in a paper tube made by himself.

In August of that year he met, in Nashville, Professor Simon Newcomb, the distinguished Washington astronomer, and received from him advice and kindly suggestion in regard to the future; and this encouragement was of much value in his efforts to accomplish something with the new instrument. In 1883 he left the photographic business, having received a fellowship in astronomy at the Vanderbilt University. He was promptly placed in charge of the observatory attached to that institution, and continued his researches with the 6-inch equatorial telescope. This instrument was superior in power to that previously used, and having a fixed equatorial mounting, with driving clock and micrometer, was much better adapted to the work of determining the absolute positions of unknown objects.

In 1888 he was offered a position in the Lick Observatory, then about to be opened with the largest equatorial and the best equipment of astronomical instruments in the world. The temptation of superior facilities for astronomical work and discovery, and the opportunity to devote his whole time and strength under these circumstances to the work of his life, left no hesitation in regard to his future course, and, much to the regret of the University and the citizens of Nashville generally, he left for Mt. Hamilton. There he began with increased enthusiasm a series of brilliant observations and discoveries, which are familiar to the astronomical world, and to the readers of scientific literature.

His long experience in all departments of photographic art was turned to practical account at the Lick Observatory in the direction of celestial photography. He was the first to photograph the Milky Way, and show the wonderful forms of its structure. The work attracted widespread attention, and down to the present time has not been equaled by any one.

Among his great achievements were the discovery of the fifth moon of Jupiter, and the finding of a new comet, by means of photography. The services of Professor Barnard in the line of astronomical research have been recognized by scientific societies. He has been a Fellow of the Royal Astronomical Society of London since 1887, and is also a member of the British Astronomical Association, the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and many other bodies. His work has lately been recognized by the French Academy of Sciences by the award of the Lalande gold medal. In 1893 the degree of Doctor of Science was conferred on him with the Arago gold medal, valued at 1,000 francs, for the discovery of the fifth satellite of Jupiter. In 1897 he received the gold medal of the Royal Astronomical Society of Great Britain, and in 1898 was elected Foreign Associate of the Royal Astronomical Society.

EDUCATION EQUALIZES FORTUNES.

EDUCATION levels all undue distinctions and removes all disparities of fortune. Many of the crucial social problems of today would be quietly and forever solved—solved to the satisfaction of all, and this republic thus made to endure forever, for the perpetuation of civilization in its most ennobling form—if education, practical education, were acquired by all.

"Give away all you can," is the advice of John D. Rockefeller, who has bestowed millions upon the educational improvement of his fellow citizens. Give it away, say we, in education. Help your struggling fellow citizen to acquire knowledge. He will repay you, and the community at large bless and honor you.

"I had a hard struggle to get a foothold," said Mr. Rockefeller, as quoted by "Success." "As a boy just out of school, I found myself looking for a situation early in life. I walked all over town in an attempt to find something to do. I visited every railroad office, every store, and, in fact, every place in the city where I thought I could find employment. Everywhere I met with discouragement, until I found one man, God bless him, who took me into his office and gave me work, and that man was H. B. Tuttle.

"That was the beginning, and a few years later I started a little business of my own, with a partner. In a short time came a crisis in our affairs, and it was necessary for our young firm, which was beginning to branch out, to raise more money. I remembered my friends and acquaintances, and called on them, one after another. Many expressed the most profound interest in our firm, but that's all."

Mr. Rockefeller then declared that at this critical moment he bethought himself to try the bankers, and finally visited the office of a dear friend, Mr. T. P. Handy. Mr. Handy, after hearing Mr. Rockefeller's statement, placed at his disposal the sum of $2,000. Mr. Rockefeller left the bank full of hope, standing up straight and erect, and considered himself one of the business men of Cleveland.

Reading from a small yellow-covered book which was his ledger in boyhood, Mr. Rockefeller found the following item: "Income from December 26, 1855, to January 26, 1856, $50; and I lived within my income! Out of that I paid my wash-woman, my board, and saved a little and put it away. I see that I paid in the Sunday School one cent, which was all I could afford. I was as independent in those days as Mr. Astor. I remember the clothes I bought; not fashionable, but cheap and good." For the year beginning November, 1855, to November 1856, Mr. Rockefeller's clothing cost him just $9.00. This man, whose clothes cost nine dollars a year, has given $7,000,000 to the University of Chicago, and his other charities are so munificent that he employs a man on a large salary to look after them.

The richest man in the world is, Mr. Rockefeller might have added, he who has useful knowledge sufficient to make his life purposeful, honest, and happy.

THE CONQUEST OF KNOWLEDGE.

THE maxim that "Labor conquers all things," holds especially true in the case of the conquest of knowledge. The road to learning is alike free to all who will give the labor and the study requisite to gather it; nor are there any difficulties so great that the student of resolute purpose may not surmount and overcome them. It was one of the characteristic expressions of Chatterton, that God had sent his creatures into the world with arms long enough to reach anything if they chose to be at the trouble. In study as in business, energy is the great thing. We must not only strike the iron while it is hot, but strike it until it is made hot. It is astonishing how much may be accomplished in self-culture by the energetic and the preserving, who are careful to avail themselves of opportunities, and use up the fragments of spare time, which the idle permit to run to waste. Thus Ferguson learned astronomy from the heavens while wrapped in a sheepskin on the highland hills. Stone learned mathematics while working as a journeyman gardener; Drew studied the highest philosophy in the intervals of cobbling shoes; and Miller taught himself geology while working as a day laborer in a quarry.

CHARACTER BUILDING.

CHARACTER building is the great work of the teacher. If men are not trained to be honest, persevering, energetic, and progressive, to be well-balanced in their character, all their knowledge is in vain. This country is looking for strong men, for leaders, for steadfast men, for men of character, fitted by technical education for leadership in the trades and professions.

MODERN MECHANICAL PROGRESS.

IN THE useful and practical arts, many inventions and contrivances, to the production of which the degree of ancient knowledge would appear to us to have been adequate, and which seem quite obvious, are yet of late origin. The application of water, for example, to turn a mill, is a thing not known to have been accomplished at all in Greece, and it is not supposed to have been attempted at Rome till in or near the age of Augustus. The production of the same effect by wind is a still later invention. It dates only from the seventh century of our era. The propulsion of the saw by any other power than that of the arm was treated as a novelty in England so late as the middle of the sixteenth century. The Bishop of Ely, ambassador from the Queen of England to the Pope, says he saw, "at Lyons, a sawmill driven with an upright wheel, and the water that makes it go is gathered into a narrow trough, which delivereth the same water to the wheels. This wheel hath a piece of timber put to the axletree end, like the handle of a broch (a hand-organ), and fastened to the end of the saw, that it continually eateth in, and the handle of the same is kept in a rigall of wood from severing. Also the timber lieth, as it were, upon a ladder, which is brought by little and little to the saw by another vice." From this description of the primitive power saw, it would seem that it was probably fast only at one end, and that the broch-handle and rigall performed the part of the arm in the common use of the hand-saw.

It must always have been a very considerable object for men to possess, or obtain, the power of raising water otherwise than by mere manual labor. Yet nothing like the common suction pump has been found among rude nations. It has arrived at its present state only by slow and doubtful steps of improvement; and, indeed, in that present state, however obvious and unattractive, it is still something of an abstruse and refined invention. It is still unknown in parts of Asia, Africa, and the New World, beyond the pale of European settlements, or the reach of European communication. The Greeks and Romans are supposed to have been ignorant of it, in the early times of their history; and it is usually said to have come from Alexandria, where physical science was much cultivated by the Greek school under the patronage of the Ptolemies.

These few and scattered historical notices of important inventions have been introduced only for the purpose of suggesting that there is much which is both curious and instructive in the history of mechanics; and that many things, which to us in our state of knowledge seem so obvious that we should think they would at once force themselves on men's adoption, have, nevertheless, been accomplished slowly and by painful efforts.

But if the history of the progress of the mechanical arts be interesting, still more so, doubtless, would be the exhibition of their present state, and a full display of the extent to which they are now carried. The slightest glance must convince us that mechanical power and mechanical skill, as they are now exhibited in Europe and America, mark an epoch in human history. Machinery is made to perform what has formerly been the toil of human hands, to an extent that astonishes the most sanguine, with a degree of power to which no number of human arms is equal, and with such precision and exactness as almost to suggest the notion of reason and intelligence in the machines themselves. Every natural agent is put relentlessly to the task. The winds work, the waters work, the elasticity of metals works; gravity is solicited into a thousand new forms of action; levers are multiplied upon levers; wheels revolve on the peripheries of other wheels.

A MILLIONAIRE CLERK.

THIS is the plain tale of a young man, working in his father's office daily from nine o'clock in the morning until four o'clock in the afternoon; who associates with the clerks and does his work as though he were one of them, on a salary of $15 a week; who neither smokes nor drinks, and finds no pleasure in the theatre; whose chief enjoyment is church work, and whose favorite recreation is swimming, skating, or a drive in the park. And yet this young man, if he lives, and he is in the best of health now, will some day undoubtedly be the richest man in the world.

He is John D. Rockefeller, Jr., the only son of his multimillionaire father, and probable heir to a fortune so vast that its owner now says that he cannot estimate it within $10,000,000 or $15,000,000. Whether this fortune is $200,000,000, as is estimated, not even Mr. Rockefeller can tell.

In his tastes, his every-day habits, his pleasures, and his beliefs, young Rockefeller

is a most striking contrast to the ordinary son of the millionaire father. In him is proved beyond all doubt the old saying that "blood will tell," for his parents' industry, their religious nature, and love of home are strongely accentuated in him as in them.

Possessed of a fortune that would enable him to gratify any extravagant wish, to pay $500,000 a year for a yacht and think it no waste, to support a racing stable, or to buy a princely estate, he wants none of these. It is to his mind pleasanter to work daily in his father's office, to live quietly at home, and devote his time to religion and charity.

It is not because of lack of opportunity for other things that young John D. Rockefeller, Jr., lives as he does. His position is such that he would be welcomed in society should he wish to attend any of the fashionable functions to which so many people devote their lives. His name and his money would gain him the entrance to houses closed against others not so fortunately situated.

Yet the man wants none of these things, which are the prerogatives of his place. Rather than spend his time thus, he devotes it to the simple enjoyments in which he finds his greatest pleasure, to the quiet evenings at home when he and his father, with their violins, unite in concerts with the young man's sisters, while the mother listens as the sole auditor. The family home, where a life is led as simple as if in a small country village in Ohio, instead of being in the center of the millionaire's district in Fifth Avenue, is at 4 West Fifty-Fourth Street.

During the day the young man works as steadily and faithfully as any of his father's employes, and besides puts his heart to the task, for he is training to manage the vast property that his father has built up. But once away from his desk, the cares of the office are out of his mind, and he looks forward to a pleasant evening at home. The family habits are still affected by the customs they observed in the early days in Ohio.

It is in the church that the young man shows the deepest interest in anything aside from business. He is twenty-seven years old now, but like his father and mother has been since a child a constant attendant at church. Since coming to New York he has become a member of the Baptist Church in Forty-Sixth Street, of which Dr. Faunce is the pastor. There his father for years taught a Bible class and Mrs. Rockefeller now has one. Until recently John D. Rockefeller, Jr., was a member of his mother's class. Since his return from college life at Brown, he himself has had charge of a class of boys, while his sisters for years had their classes.

In a life like this John D. Rockefeller, Jr., finds his pleasure. Aside from his horse, his chief outdoor pleasure is swimming and skating. For the latter a pond has been arranged back of the house, and there, shut off from view from the street, he can enjoy his exercise.

But for a man with present opportunities like his, and a future which seems illimitable in its prospects of wealth, there is no more unique life than that led by young Rockefeller. His work is as regularly done as though he depended on a weekly wage for his support, and his pleasures are as simple as those of a country lad.

THE FITTEST SURVIVE.

YOUNG men on the threshold of life's career must know that they are to be subjected to the law of natural selection. In the great struggle for existence none but the fittest survive. How many among you, young men of today, will emerge unscathed from the terrible ordeal? Will any of you be rolled up as moral wrecks on the sands of time? We would not be prophets of evil, but we impress upon you an adequate conception of the severity of the test through which you must all pass.

Society is a hard master. Your fellow men will sift you as wheat. Some of you are even now fighting an unequal battle with poverty and friendlessness. Others are exposed to the still greater dangers of wealth and ease. All alike must be tried as by fire before the world can decide what manner of men you are.

That you may pass the ordeal in triumph, you must choose your career in life wisely. For this end study your own powers, tastes, and tendencies. Your profession should be the choice of your mature mind, not the whim of boyhood. It must be your own choice, not that of interested and partial friends. Fix your thought upon its drudgeries and annoyances, not alone upon its possible honors and rewards.

When your choice has once been made, it should, except for extraordinary considerations, be final. Like the Spanish adventurer, burn your ships behind you. Cut off all hope of retreat. Put your whole powers into the channel you have marked out. You will never feel the full weight of the disagreeable elements of your profession till you have gone too far to retreat. Remember that almost all the work that strengthens character is drudgery pure and simple.

SUCCESS AND PHYSICAL HEALTH.

THE success of men depends in no slight degree on their physical health, and a public writer has gone so far as to say that "the greatness of our great men is quite as much a bodily affair as a mental one. A healthy breathing apparatus is as indispensable to the successful lawyer or politician as a well-cultured intellect."

The thorough aeration of the blood by free exposure to a large breathing surface in the lungs is necessary to maintain that full vital power on which the vigorous working of the brain in so large a measure depends. The lawyer has to climb the heights of his profession through close and heated courts, and the political leader has to bear the fatigue and excitement of long and anxious debates in a crowded house. Hence, the lawyer in full practice and the parliamentary leader in full work are called upon to display powers of physical endurance and activity even more extraordinary than those of the intellect—such powers as have been exhibited in so remarkable a degree by Brougham, Lyndhurst, and Campbell; by Peel, Graham, and Palmerston—all full-chested men.

Though Sir Walter Scott, when at Edinburgh College, went by the name of "The Greek Blockhead," he was, notwithstanding his lameness, a remarkably healthy youth: he could spear a salmon with the best fisher on the Tweed, and ride a wild horse with any hunter in Yarrow. When devoting himself in after life to literary pursuits, Sir Walter never lost his taste for field sports; but while writing "Waverly" in the morning, he would in the afternoon course hares. Professor Wilson was an athlete, as great at throwing the hammer as in his flights of eloquence and poetry; and Burns, when a youth, was remarkable chiefly for his leaping, putting, and wrestling. Some of our greatest divines were distinguished in their youth for their physical energies. Isaac Barrow, when at the Charterhouse School, was notorious for his pugilistic encounters, in which he got many a bloody nose; Andrew Fuller, when working as a farmer's lad at Soham, was chiefly famous for his skill in boxing; and Adam Clarke, when a boy, was only remarkable for the strength displayed by him in "rolling large stones about"—the secret, possibly, of some of the power which he subsequently displayed in his manhood in rolling forth large thoughts.

While it is necessary, then, in the first place, to secure this solid foundation of physical health, it must also be observed that the cultivation of the habit of mental application is quite indispensable for the education of the student.

DIVERSITY IN EDUCATION.

EVERY youth of eighteen is an infinitely complex organization, the duplicate of which neither does, nor ever will, exist. His inherited traits are different from those of every other human being; his environment has been different from that of every other child; his passions, emotions, hopes, and desires were never before associated in any other creature just as they are in him; and his will force is aroused, stimulated, exerted, and exhausted in ways wholly his own. The infinite variety of form and feature, which we know human bodies to be capable of, presents but a faint image of the vastly deeper diversities of the minds and characters that are lodged in these unlike shells. To discern and take due account of these diversities, no human insight or wisdom is sufficient, unless the spontaneous inclinations, natural preferences, and easiest habitual activities of each individual are given play. It is for the happiness of the individual, and the benefit of society alike, that these mental diversities should be cultivated, not suppressed. The individual enjoys most that intellectual labor for which he is most fit; and society is best served when every man's peculiar skill, faculty, or aptitude is developed and utilized to the highest possible degree. The presumption is, therefore, against uniformity in education, and in favor of diversity at the earliest possible moment.

EDUCATION'S FIRST STAGE.

THE first stage in the education of the true worker is self-consciousness; the final stage is self-forgetfulness. No man can enter the final stage without passing through the initial stage; no man can enter the final stage without leaving the initial stage behind. One must first develop intense self-consciousness, and then must be able to forget and obliterate himself. One must first accept the most exacting discipline of the school, and then must forget that schools exist. The apprentice is the servant of detail; the master is the servant of idea; the first accepts methods as if they were the finalities of art; the second uses them as mere instruments.

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

IN THE INTERNATIONAL CORRESPONDENCE SCHOOLS,

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FROM BRICKLAYER TO ARCHITECT.

Before enrolling in the Schools, and while pursuing the study of the Architectural Drawing Course, I was a bricklayer, and worked with my father on the mason work of several large buildings. After completing the Course I held responsible positions in the offices of two of the leading architects of Cleveland, O. I am now successfully practicing architecture, and have recently furnished plans and specifications for the new $8,000 school building that is to be erected at Corry, Pa. My success is due entirely to the Schools.—*Michael A. Crowe* (*U. 233*), *Meadville, Pa.*

BECAME A SUCCESSFUL STATIONARY ENGINEER.

It gives me great pleasure to recommend The International Correspondence Schools to any one. They have done for me more than they advertised. When I began the study of the Stationary Engineers' Course I was a locomotive engineer. The completeness and simplicity of the Instruction Papers agreeably surprised me. After completing my Course I accepted the position of chief engineer of the State Hospital for the Insane at Massillon, O. I now have charge of a complete electric light and power plant, water works, and refrigerating plant. It is through the instruction received in my Course that I have been able to obtain and hold this position.—*Clarence E. Sutton* (*H. 196*), *Massillon, O.*

FROM OFFICE BOY TO BOOKKEEPER.

In the latter part of 1896 I went to work for L. Sternberg & Co., Newark, N. J., as office boy. After I had been there about one year, a friend explained to me the methods of The International Correspondence Schools, and as I knew nothing about bookkeeping I enrolled in the Complete Commercial Course.

Since taking the Course, I have been advanced from office boy to assistant bookkeeper, and my salary has been raised three times on account of my knowledge of bookkeeping. I am still at the same work, and hope to rise higher when I have completed double entry. My success is due entirely to the Schools.—*Frank W. Mertz* (*C. C. 433*), *Newark, N. J.*

INCREASED HIS SALARY $5.00 PER WEEK.

Before taking the Wiring and Bell-Work Course of The International Correspondence Schools, I was a shoe salesman, at a salary of $8.00 per week. I still hold the same position, but receive $9.00 per week. I have one afternoon and three evenings off duty each week. This spare time I turn to advantage by doing electrical work. In this way I increase my salary $5.00 per week, making $14.00 in all. I now feel qualified to accept a position in an electrical establishment, and when the opportunity occurs, I intend to change my occupation.—*Geo. C. Jackson* (*J. B. 87*), *3960 Market St., Philadelphia, Pa.*

FROM CHAINMAN TO ASSISTANT ENGINEER.

I began work seven years ago, as chainman on an engineering corps. I have advanced in the profession to the position of assistant engineer in the Civil Engineering Department of one of the largest iron companies in this country. My work is varied, covering nearly all branches of the profession.

Without any previous mathematical education, I have been able to keep abreast of the times through the Course I have taken in the Schools. During the time I have been a student in the Bridge Engineering Course, my salary has been nearly doubled.—*Chas. L. Hower (B. 440), Johnstown, Pa.*

FROM MINER TO SCHOOL TEACHER.

I received no education as a boy, and had worked in the mines nearly twenty years when I enrolled in the Complete Coal Mining Course of The International Correspondence Schools. My progress was very satisfactory to me, as I was able to complete the Course in two years. This was largely due to the fact that all letters of inquiry for further information on any problem were very promptly and cheerfully answered. The Course not only fits a man for a mining position, but for anything else to which he may aspire. Through the knowledge gained in the Schools, I have been able to obtain a first-grade teacher's certificate, and am now teaching in the public schools of this place at a salary of $70.00 per month. I owe my present position to the Schools, and my success in teaching to the able reasoning in the Instruction Papers, which treat matters in such logical order that any one who studies can understand them.—*John Graham (C. M. 1189), Rockvale, Col.*

FROM SCHOOL TEACHER TO ARCHITECT.

I have very nearly finished the Complete Architectural Course of The International Correspondence Schools of Scranton, Pa., and wish to state that I consider the Schools the greatest educational institution that has ever been established. My Course has been of almost inestimable value to me, as I am now holding a position which I could not have filled had it not been for the knowledge gained in my Course.

When I enrolled, and while studying the Course, I was a school teacher in Triangle, N. Y. Nearly all my studying has been done after working hours, and I have been to no extra expense to get my education. I am now working in an architect's office, where I do all the estimating and draw all the plans.—*Chas. G. Baker (A. 310), Scranton, Pa.*

FROM LABORER TO COUNTY SURVEYOR.

Prior to the time when I enrolled in The International Correspondence Schools, I had principally followed mining and mechanical labor, as my education was limited to a few years' schooling when I was quite young. I felt that a technical education would enable me to earn higher wages, so enrolled in the Schools. Since completing my Course in Surveying and Mapping and obtaining a diploma, I received the nomination for County Surveyor and Road Supervisor, and was elected by a nice majority. I receive $5.00 per day for road supervising, and $7.00 per day for surveying. I shall always remember with pleasure my work in the Schools, and advise all my friends to enroll and receive the certain benefits of knowledge.—*Chas. F. Donyes (S. M. 90), Philipsburg, Mont.*

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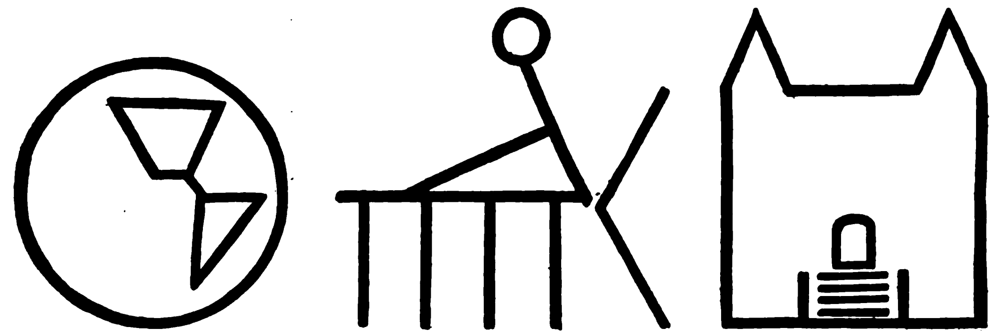
As the Ancients Would Have Written It.



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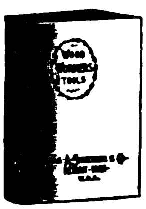

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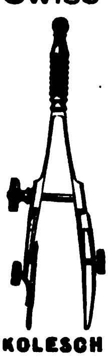

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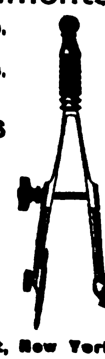

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SPLICES, KNOTS, AND BENDS.

Ernest K. Roden, Captain of Sail and Steam.

THE A B C OF THE ART OF ROPE SPLICING—HOW TO USE THE MARLINESPIKE—KNOTS, BENDS, AND HITCHES THAT ARE USEFUL IN THE WORKSHOP.

HOWEVER useful it may be to those immediately concerned, it cannot be said that the operation of splicing together two pieces of hemp rope is in itself particularly attractive or interesting, and it is more than possible that the reader will feel that his occupation, business, or profession is never likely to call for any knowledge of the art. Nevertheless, at some future time he *may* be brought unexpectedly face to face with an emergency where the ability to make a good durable splice or to tie a strong reliable knot will come in very handy, so it may not be entirely waste of time for him to read on. Moreover, it is probable that among the thousands who read this magazine every month, there are many who are more or less interested in yachting and shipping, or are employed in workshops where rope splices and rope tackle are not altogether unknown; to such the writer feels that a few practical hints from one who knows about these things will be of real value.

FIG. 1.—USING THE MARLINESPIKE.

To begin with, let us define the word "splicing." Splicing is the operation of joining two pieces of rope so as to obtain one continuous piece, with no appreciable increase of diameter at the splice.

There are several kinds of splices, but the two principal ones are the *short* splice and the *long* splice; these will be described first. Among other forms is the *eye* splice; this, and a variety of knots, bends, and hitches, will be taken up afterwards.

The principle of all splicing consists of joining, or "marrying," the strands, thinning them out, and tapering them, so that the diameter at the splice is the same or only slightly greater than that of the rope itself. In the long splice, no increase in diameter is allowed.

Until within comparatively recent years, all ropes were made of vegetable fiber teased out and spun into suitable form either by hand or machinery; but since the introduction into the rope-manufacturing industry of iron, and particularly of mild steel, steel rope is rapidly superseding all other kinds, even for running gears. For many purposes, however, fiber ropes are still used and can never be replaced by steel ones; they are made, for the most part, of either hemp, manila, or coir (cocoanut husk fiber).

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First, the fibers are spun into yarns, then the yarns into strands, and finally the strands into rope. The methods of splicing described and illustrated here apply only to these fiber ropes.

The only instruments necessary for making a splice are a marlinespike and a knife. The former is made of either iron or hard wood, is from 12 to 14 inches long, and about 1 inch in diameter at the thick end, the other end being sharpened to a blunt point about as shown in Fig. 1; it is always operated by the right hand, while the left encircles the rope. After pushing the extreme point through between the strands to be separated, the thick end is placed against the body of the operator; then, using both hands, the rope is twisted so as to render the work of opening the strands comparatively easy.

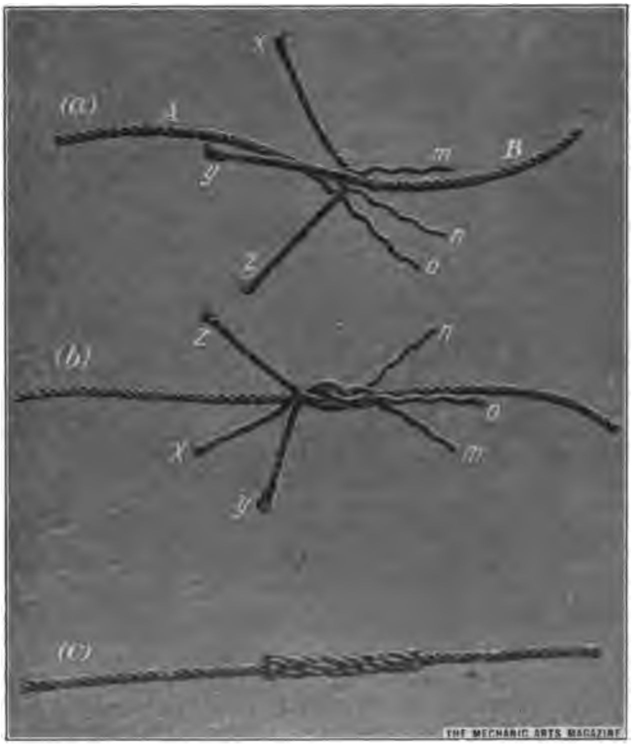


FIG. 2.—THE SHORT SPLICE.

To make a short splice: Unlay—that is, split open—the strands at the end of each rope for a distance about as shown in Fig. 2; this distance depends entirely upon the diameter of the rope, but as the proportion will be the same for all diameters, the illustration serves as a general guide; be sure to unlay enough; a few inches too much is better than too little, as the ends have to be cut off anyway. Then, place the two ends together, as shown at (*a*), Fig. 2, so that each strand lies between two strands of the other rope. Now, hold the strands *x y z* and the rope *A* in your left hand; if the ropes are too large to hold thus, fasten them together with twine; then take one of the strands, say *n*, pass it over strand *y*, and, having made an opening, either with the thumb or with a marlinespike, in the manner illustrated in Fig. 1, push this strand *n* through under *x* and pull it taut; this operation is known as "sticking." Proceed similarly with strands *m* and *o*, passing each over the immediately adjoining strand and under the next one. Perform precisely the same operation with the strands of the other rope, passing each strand over the adjoining one and under the next, thus making the splice appear as at (*b*), Fig. 2. Now, in order to insure security and strength, this work must be repeated by passing each strand over the third and through under the fourth, then, after subjecting the splice to a good stout pull, cut off the ends of the strands, and you have the finished splice as shown at (*c*), Fig. 2.

In slings and straps used for heavy work, the strands should be passed twice each way, and one-half of each strand should be "whipped," or bound, with twine to one-half of the rest, thus preventing the strands from "creeping through" when the splice is taxed to the full capacity of the rope.

In the short splice, the diameter at the join is rather greater than that of the rope, for which reason it is not a suitable splice where the rope is to be used in tackles and pulley blocks, or in places that will not admit anything larger than the rope itself. In such cases the long splice is used; this, when properly made, the untrained eye can hardly distinguish from the rest of the rope. To make the long splice: Unlay the ends as before, but about three times as far, and

place them together, as shown at (*a*), Fig. 3, in the same manner as for the short splice. Then unlay one of the strands, say *x* of the right-hand rope, and in the groove thus made lay the strand *n* of the left-hand rope, taking good care to give this strand the proper twist, so that it falls gracefully into the groove previously occupied by strand *x*. Do likewise with strands *y* and *m*, unlaying *y* gradually and in its place laying the strand *m*; the result is shown at (*b*) Fig. 3. Now, leaving the middle strands *p* and *g* in their original positions, cut off all the strands, as shown at (*b*); then relieve strands *n* and *x* of about one-third of their yarns, and with what splice compares with the rope in strength and durability; in other words, is the splice as strong as the rope that it joins? In the opinion of the writer, it is; the splice is quite as strong and durable as the rope itself. This is proved by the fact that on shipboard it is very rarely one hears of a rope or sling snapping in the splice. When such a thing does occur it is generally easy to trace the origin of the splice to some "greenhorn" of a sailor, or, if on a steamer, to some member of the engine department who parted with his teacher in rope splicing a little too soon. However, the *theoretical* version of the matter is that the splice is about one-eighth weaker than the rope itself; this is on the safe side,

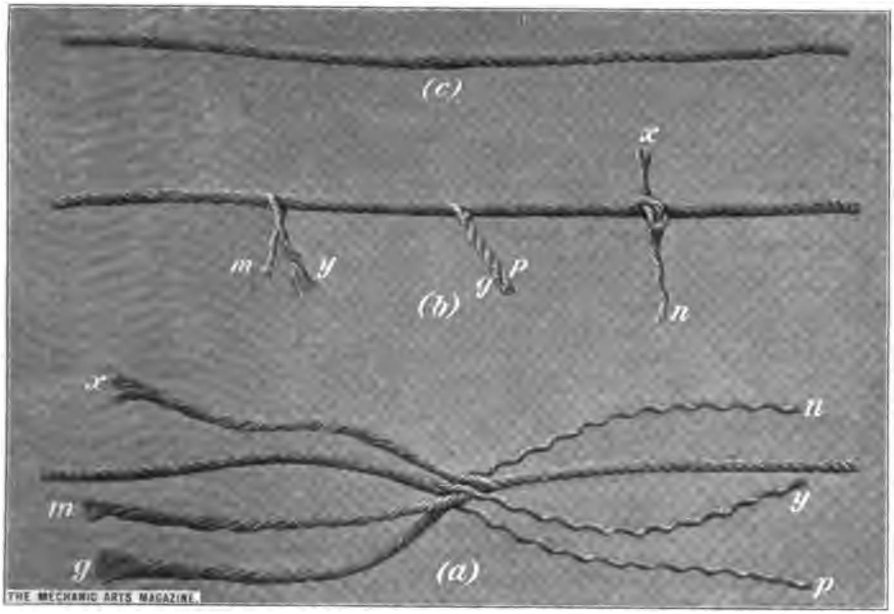


FIG. 3.—THE LONG SPLICE.

is left cast an overhand knot as shown —exactly as shown; no other kind of knot will do. Pull this knot taut and dispose of the ends as in the short splice, by passing them over the adjoining strand and through under the next, cutting off a few yarns at each "stick." Proceed similarly with strands *p* and *g*, and *y* and *m*. The splice, when it is completed, appears as at (*c*), Fig. 3. Sometimes the overhand knot is made without first thinning the strands, and then split and the half strand put through as described, but by doing so, the surface of the splice is never as smooth as by the other method, which, for strength and neatness, is second to none.

A question frequently asked is how the

and makes allowance for indifferent work.

Another splice, and one that is as common and useful as the two already described, is the *eye* splice, illustrated in Fig. 6. To begin this, unlay the end of the rope about as far as for the short splice, and bend into the required size of eye, as shown at (*a*). Then tuck the end of the middle strand *y* under one of the strands of the standing part—having previously made the necessary opening with the marlinespike—and pull tight, getting what is shown at (*b*). Now push the strand *x* from behind, and under the strand on the standing part next above that under which the middle strand *y* was passed, so that it will come out where *y* went in, getting

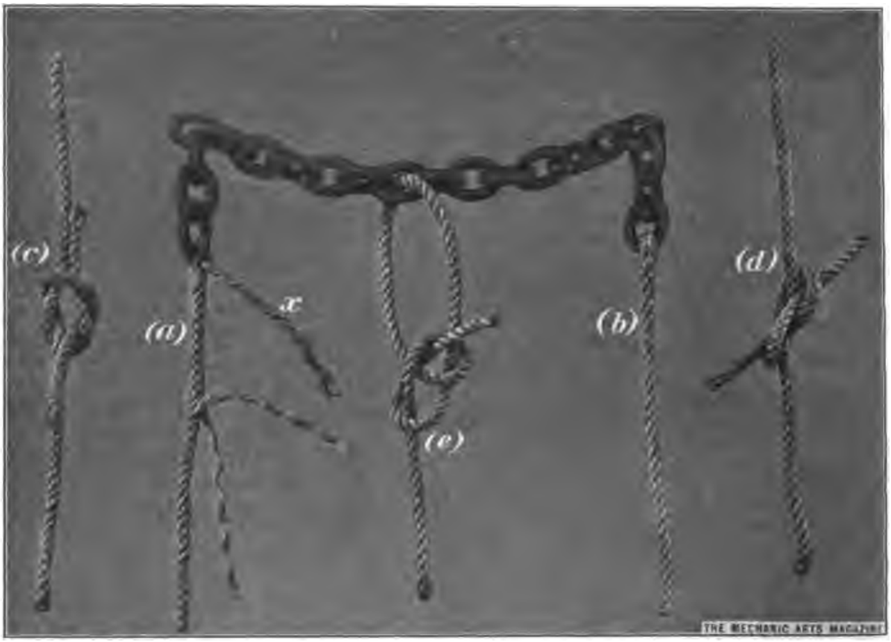


FIG. 4.—THE OVERHAND AND THE BOWLINE KNOT, AND A USEFUL SPLICE.

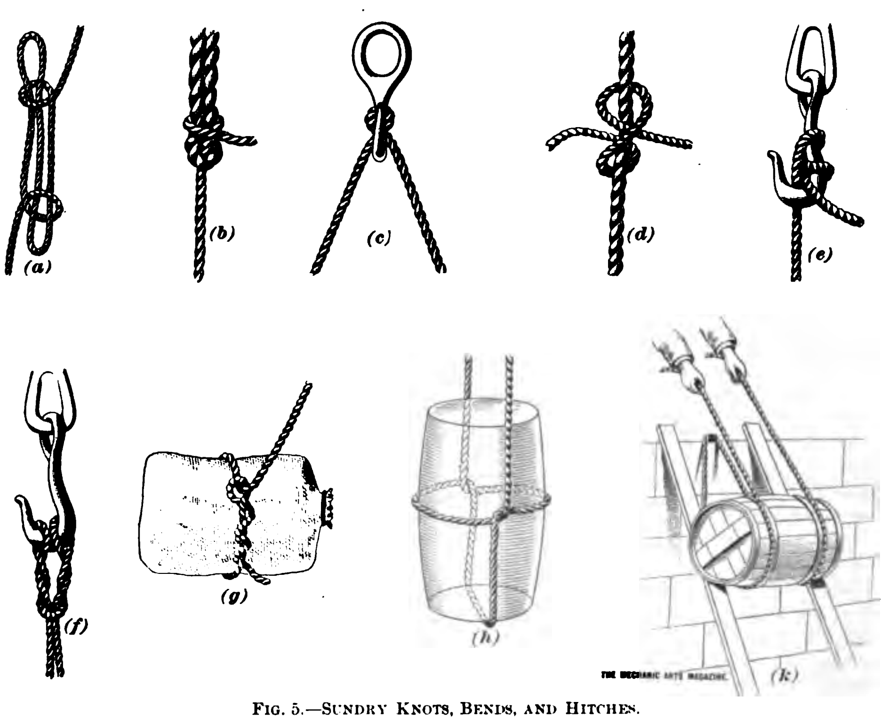


FIG. 5.—SUNDRY KNOTS, BENDS, AND HITCHES.

what is shown at (*c*); then pass the third strand *z* under the remaining free strand in the standing part, next to the one under which *y* was passed, getting (*d*). Now pull the strands taut, and from each cut out one-third of the yarns; pass each one over the adjoining strand and then through under the next, as in the short splice; then cut out one-half of the yarns, and tuck each one under its corresponding strand for the third time; give it a good stretching, cut off the ends, and thus complete the splice as shown at (*e*).

These three splices, the short, the long, and the eye, may justly be termed the A B C of the art, for if they are once thoroughly mastered the making of others becomes of little difficulty, since all other forms and varieties are in general but modifications or applications of them.

In Fig. 4, (*a*) and (*b*) show how to splice a small rope to a chain. To make this splice: Unlay the strands of the rope and reeve two of them through the end link; then unlay the third strand for about the distance shown, and in its place lay one of the other strands, the same as in making the long splice; make an overhand knot and dispose of the ends in the usual way; dispose of the third strand *x*—one of the two reeved through the link—as when making the eye splice, by "sticking" near the link; cut off the ends, and the splice is complete as shown at (*b*), Fig. 4. This is a very neat and strong splice, and can be used with advantage in connection with chains that are "tailed," or lengthened, with a rope that has to pass through sheaves or places that do not allow any increase of diameter in the rope.

Having made the reader acquainted with the principal splices in existence, it will, perhaps, not be out of the way to add a few words about the making of sundry bends and hitches connected with the handling of cordage. Among landsmen in general and persons not familiar with the use of ropes, the ignorance displayed in this direction is astonishing, there being very few indeed who know even how to knot two pieces of rope together properly. Nine persons out of ten will make the knot as at (*d*), Fig. 4. And why? Simply because of that everlasting human instinct to commit error, by which we are all affected more or less. Such a knot hardly amounts to anything, as the least pull will cause it to slip. At (*c*), in the same illustration, the correct way to make the knot is shown.

Another error is indicated at *b* in Fig. 7; this is frequently committed by amateur yachtsmen when belaying or securing a rope—say the sheet of a sail—to a cleat. If, during a cruise, the boat is caught in a sudden squall that demands the immediate slacking up of the sheet, the result of this method of fastening it is more likely than not to prove fatal to the occupants of the boat, by causing immediate capsizing. As

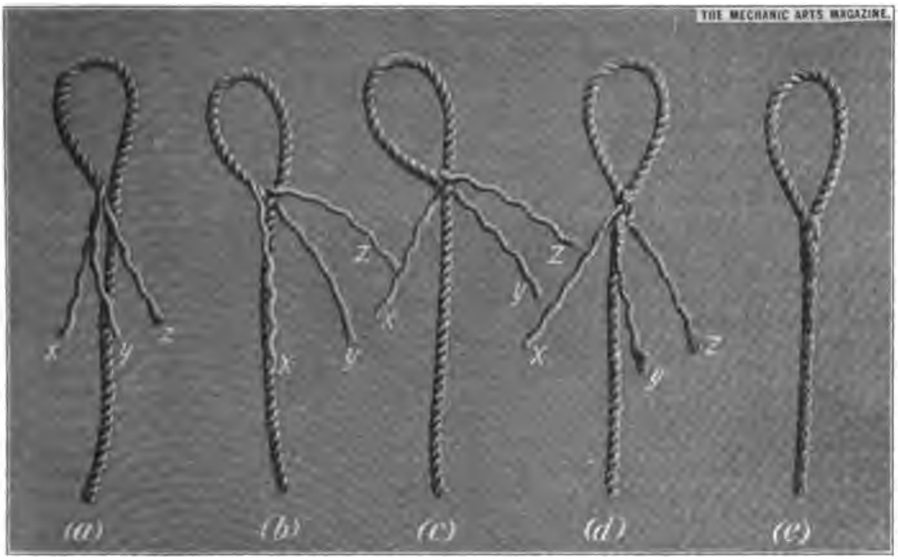


FIG. 6.—THE EYE SPLICE.

will at once be understood by a glance at the illustration, the increased strain on the sheet in such a case will jam the rope and render it impossible to ease off the sheet. Of the many cases of boats capsizing, most are due to this way of belaying the sheet. At *a*, Fig. 7, is shown the correct way to secure the rope.

A very useful knot that should be mastered by every mechanic and by all persons in any way connected with shipping is shown at (*e*), Fig. 4; by seamen this is known as the *bowline* knot. To make it, take the end of the rope in the right hand and the standing part in the left, and lay the end over the standing part. Then, with the left hand, turn over the end a *bight* (a loop, or turn) in the standing part, pass the end over and around the standing part, and through the bight again, thus completing the knot; all this is shown with perfect clearness in the illustration.

As an example of the many uses to which in emergencies the bowline knot can be applied, the following report found in the news columns of one of the New York dailies will perhaps be interesting: "At about half-past four o'clock this morning a patrolman on duty near pier No. 15, East River, was attracted by distressing cries for help that apparently came from the water-front. He hastened toward the end of the pier, and through the haze overhanging the water made out a human being struggling against the tide, which was slowly carrying him down toward the bay. The officer, quickly realizing that the drowning man was too far from the pier to be reached by an ordinary boathook, jumped down to the deck of a lighter that lay alongside the pier and getting hold of a rope made in the end of it a *bowline knot* large enough to admit the body of a man; this he threw out to the nearly exhausted struggler, shouting to him not to try to hold on to the rope but to get the loop over his head and under both his arms. The man finally succeeded in doing this, the line being paid out as he drifted away, and the officer, feeling that the rope had a good hold, began to haul in, and with the assistance of a brother officer who had responded to his call, the drowning man, now almost unconscious, was lifted on to the deck of the lighter. Here he soon revived and was able to give his name and also the name of the vessel from which he fell into the river. The policeman attributed the saving of this man's life solely to the bowline knot, as the man was too weak to have held on with his hands until the deck had been reached."

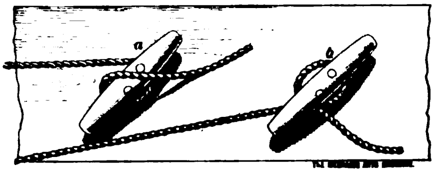


FIG. 7.

In Fig. 5 are illustrated a few methods of applying slings and ropes to hooks, barrels, etc., and a few other wrinkles useful to those engaged in workshops. Should a rope be too long for some temporary purpose, do not cut it, but arrange it as at (*a*); if several bights are laid up to shorten the rope to the required length, pass the standing part through and over the ends of all, and pull tight. At (*c*) is shown how a sling or strap should be applied to a hook when the rope spreads away to its load; this hitch prevents the sling from slipping in the hook in case the load comes in contact with some obstruction while being hoisted. At (*b*) and (*d*) is shown how a smaller rope should be secured to one of greater diameter. The Blackwall hitch is illustrated at (*e*); except for very light loads, this should be made with the end *twice* around the hook (called a *double* hitch), as in the figure; experience has proved that this is the safest way, since with only one turn, the end is liable to "creep" when subjected to a heavy pull, especially in damp weather, when the moisture absorbed by the rope serves as a lubricant. When a rope is too long to conveniently secure its end to a tackle, a bight of it twisted as at (*f*) is very handy and useful; to make this hitch, commonly called a *cat's paw*, take hold of the rope with both hands at places about two feet apart and twist it two or three times either way; then apply the ends of the loops thus made to the hook; the twisting prevents the rope from becoming jammed, and the hitch is very easily undone. At (*g*) is shown a *timber* hitch, so simple that explanations are unnecessary. At (*h*) is shown how to apply a rope to a barrel or similar vessel when, for some reason or other, it is desired to hoist it in a vertical position. At (*k*) is shown what is known as a *parbuckle;* this hitch is used for raising a heavy cask or similar load with a single length of rope. The illustrations that are here given explain the last two hitches much better than can be done in words.

DESIGNING MACHINERY.

D. Petri-Palmedo.

MACHINE DESIGNING AS A PROFESSION—TWO WAYS OF DESIGNING—DESIGNER AND DRAFTSMAN. SHOP AND DRAFTING ROOM—THE PRACTICAL EXPERIENCE NECESSARY TO A DESIGNER.

PART I.

MACHINE designing is a profession, and as such involves certain attainments, mental and otherwise, distinctly its own. But it is not represented "officially," so to speak, in the long list of professions that have branched from the parent stem of engineering, neither do our colleges confer degrees on those who make machine designing their special study. True, the mechanical engineer—the M. E.—is supposed to know something in a general way about machinery, but he may or may not be a machine designer; his title, therefore, is not sufficiently distinctive to be applied to the machine designer, neither does it cover all the ground, because machine designing forms a part of every *other* branch of the engineering profession, and the mechanical engineer is little less dependent on the machine designer proper than is the civil or the mining engineer, the steam or the electrical engineer, the millman or the metallurgist, the chemist or the technologist. In view of these facts and the consequent steady demand for competent designers, it is more than surprising that machine designing is not recognized as a profession by itself, that it is looked on by many of the diplomaed members of the engineering profession—the M. E.'s, E. E.'s, C. E.'s, and so forth—as a sort of "handicraft" indispensable, may be, as an ally, yet by no means entitled to be placed on a par with their own scientific calling. Good machine designers can stand the slight; they experience no difficulty in holding their own. The most regrettable thing about it is that, on account of the meager appreciation from the other branches of the profession, the needs of the future machine designer are not fitly provided for at our colleges and technical schools, and that, in the large workshops and engineering establishments of our country, few facilities are offered for the development of competent designers. The road that the would-be designer has to travel in order to gain his end is therefore a hard and laborious one, and its difficulties have turned aside many a young man who, by his talent and scientific knowledge, was eminently fitted for the profession. Good machine designers are, therefore, comparatively rare, as any one who has ever had need of their services will admit. This may strike many as a rather bold statement, in face of the fact that American machinery is finding its way everywhere and that American designs are unsurpassed.

But there are two ways of designing machinery; one we will call the method of *evolution*, and the other the *synthetic* method (which means "a method of deducting consequences from general principles"). The first is the older and formerly the only possible method, but it is still pursued by the majority of machine builders; it is the cut-and-try method, by which an idea is evolved, first in a crude way, and brought to final perfection by slow degrees, step by step, through years of experimenting, by altering and adding and changing about. In this manner most of the wonderful labor-saving machinery has been evolved. That this is a slow and expensive process no one will deny. It will also be apparent that to a certain extent any new machine or device will have to go through an evolution of this sort. But, with the enormous amount of experience that has been had during the last fifty years, it should be possible, and *is* possible, to at once produce a machine that will do the work required of it to a reasonable degree of perfection, so long as the principles involved in its construction are not beyond what are well known. This is what constitutes the other method—the synthetic. That it is not followed to as great an extent as might be expected is evidenced by the fact, well known to the public in general, that, in the line of machinery, it is next to impossible to have anything new built without the expenditure of an enormously disproportionate amount of time and money. This expenditure has long been accepted as a necessary evil, and is naturally ascribed to greed, almost bordering on dishonesty, on the part of machine builders, which, however, is only partially true, it being a fact that in spite of the

enormous prices asked and paid for special work, machine builders actually do not as a rule find it profitable to execute it—to do a general machine business, as the saying goes—but prefer to manufacture some specialty. The seeming contradiction presented by these facts is explained by the method of design employed: When, in order to obtain one *perfect* machine, it is necessary to build six machines, each a little nearer perfection than its predecessor, it is not to be wondered at that the aggregate cost of the job, and therefore the price asked by the manufacturer, is about six times too great. But, if there is such a thing as machine designing, have not the public a right to expect that a problem shall be solved "first shot," the same as it is in bridge designing? What should we think of the civil engineer who had to span a river half a dozen times before getting the final and satisfactory bridge? No wonder our brethren of the other branches cry down our designing as empty guesswork. As a further proof of the above assertions, it will be shown later that not a few of our best and most admired machines bear still the distinct earmarks of the evolutionary process.

This state of affairs is due to the scarcity of competent designers. Some of the larger machine-building concerns realize this, and have among their highest-salaried employes a number of designers, quite distinct from the ordinary drafting force. Some call them their consulting engineers, some their inventors, following in this respect the example of Thos. A. Edison, who first, with more or less justification, called inventing a profession; they themselves would most likely prefer the name designer rather than consulting engineer, which means everything and nothing, and rather too than inventor, which, in spite of Edison and the dictionaries, carries with it a notion of the accidental, or of some sort of "mahatma" inspiration, which is contrary to what is acknowledged to be true, namely, that machine design is based on hard work, pure research, and long experience.

In the above paragraph we have spoken of designers "quite distinct from the ordinary drafting force." We have also stated that in our large shops few facilities are offered for the development of competent designers. These two things are closely connected. A greater distinction should be made between designers and draftsmen by all parties concerned, be it manager, engineer, or mechanic. On the part of the employer it is unreasonable to expect a man to whom he pays a draftsman's salary to be at once a designer; on the part of the mechanical engineer it is a case of "sour grapes" if he fails to make such distinction and to recognize the designer as his equal; on the part of the artisan and mechanic it is a case of a long-nourished grudge—only too well founded in many cases—against every one connected with the drafting room, which dims his sense of distinction, and prevents him from recognizing in the designer his best friend and ally.

We ask to be allowed to dwell on the subject of the grudge just mentioned, albeit an old story.

At the peril of engendering the wrath of the shop foreman or superintendent, let it be stated that the drafting room ought to be the fountain head of the machine shop; it should have more to say than it generally has, and its rulings should be final—always under the strict understanding, however, that it is competent to exert such authority. A gang of mere draftsmen alone will not do. We cannot blame the practical machinist—who knows his business, and from whose ranks have risen, by hard struggle, our most successful machine designers—when he most strenuously objects to the blunders of the young college-graduate M. E., especially if the latter, conscious of possessing sound and superior knowledge, shows a certain amount of, albeit pardonable, conceit; or to being advised so and so by the former office boy, who grew to be a member of the drafting force from numbering and filing drawings, and making blueprints; or even to abiding by the judgment of his former associate in the machine shop, who has in some way mastered the noble art of mechanical drawing and no more; not to speak of the many other types of so-called mechanical draftsmen, the "me-toos," who, after many shipwrecks in life, have taken to drafting—or, better, to tracing lines—as a congenial and easy way of making a scant living. Such men, the young graduate not excepted—though we are sorry to have placed him for the time being in company with those that in his judgment are doubtless inferior to himself—should not be allowed to assume authority over the man of the shop. It is a humiliation to the latter that he cannot be expected to bear. We will assume that, as in every high-class drafting room, the force is presided over by an able chief, assisted by one or two competent designers, and that as is usual the former transmits the orders from the drafting room to the shop. If the

chief is the right man in the right place, there will be no antagonism between the departments.

The above seeming deviation from our subject nevertheless brings us right back to it; for it is upon the character of the relation between drafting room and shop (people more fond of scientifically expressing themselves would say between *theory* and *practice*) that depend the facilities offered by a concern for the development of machine designers. Shutting off all communication between drafting room and shop, save the legitimate channel through the chief, must effectually deprive the draftsman of all means of development as a designer; on the other hand, too free a communication produces the grudge already referred to. A system that is successfully employed by a Brooklyn concern, and gives the draftsman opportunity to learn, is a great help to the draftsman, increases the efficiency of the department, and, last but not least, is not apt to disturb the peaceful relations between the drafting room and the shop, is as follows: An order having been passed in from the office, it is assigned by the chief to one of the designers, who selects one or two of the draftsmen. The plan to be followed having been outlined and determined by the designer, it is carried out in detail by the draftsman, under the supervision of the former. All drawings bear the signatures of the chief, the designer, and the draftsman, *as such*, before they are sent into the shop. The responsibility is thus clearly apportioned. The draftsman, being the lowest-salaried man in the combination identified with the job, is detailed to the shop, and charged with the following up of the work as it proceeds, reporting any trouble that may arise. To be sure, he is quickly made acquainted with whatever blunders he may himself have committed as draftsman; he also hears the mechanic's criticism on the design of his superior, and, reporting this, hears the latter's refutation or approval. He has helped to build the machine in theory, that is, on paper, and he sees it take actual form; he realizes the difficulties attending the making of the various parts, forms ideas as to time and expense—in short, learns a lesson of great value to himself as well as to his employer, and a few years of such practical instruction are apt to make him a pretty fair designer.

In thus recommending a plan to be followed by a machine-building concern that is willing to offer advantages to their draftsmen, it is intended to indicate the course to be pursued by the man who wishes to become a successful designer, rather than to give points to chiefs and managers, as in most cases the would-be machine designer will have to gain his end by his own individual efforts. The series of articles here begun is meant to aid him in these efforts.

In the above, speaking of drafting-room practice, we have tacitly assumed that the position from which a designer starts on his career is that of draftsman. This assumption is correct. Drawings are the language of the designer, and he must be a good mechanical draftsman first of all. Where and in what manner his proficiency in the art has been acquired is quite immaterial; the college graduate stands no better show than the machinist draftsman. Next, what has been said points decidedly to the advantage of gaining experience by shop practice. In this respect the machinist has somewhat the advantage over the college M. E. He has, no doubt, by long association with the methods of the shop, gained a valuable and *perfect understanding as to the best ways for the mechanical execution of work*, the capacities of the various machine tools, and so forth. The information of this nature that is imparted to the student of mechanical engineering in our technical colleges, equipped with more or less extensive workshops, can at best be but fragmentary, and must be regarded as a meager substitute for actual training in the commercial workshop. Not that we wish to run down this part of the college training; on the contrary, the maintenance and constant improvement of these college workshops deserve fervent approval, especially in view of the difficulty young men experience in gaining admission, as apprentices, to large establishments, and even if admitted, the difficulty of learning much within a reasonable length of time—there being no one to teach them. The student who is fortunate enough to secure the position of apprentice under a master who understands his object and is sufficiently liberal to help him gain it, should eagerly grasp and improve every opportunity to learn, as being of inestimable value to him in his future career as a designer.

We have emphasized by italics in the above paragraph the words "perfect understanding as to the best ways for the mechanical execution of work." We did so because in the main this is *all* (though forming a goodly portion of the total sum of attainment needful to make a designer) that an apprenticeship can give him, and is all that he need

strive for while serving it. The acquisition of superior dexterity in handicraft, forging, filing, turning, patternmaking, molding, etc. is *not* necessary. The designer's handicraft is drafting.

Again, long association with shop work alone does not, strange as this may at first seem, help to impart to the would-be designer those notions of combinations, shapes, and dimensions that constitute his needful experience. This being a matter of considerable importance, it is well to more fully explain: Suppose a machinist has worked for a considerable length of time in a shop where machines of a certain class are made; he will probably know all the parts of these machines, their shapes, their dimensions, their functions in the combination, and, as the machines work well, will consider them patterns after which pieces in similar combinations should be modeled. This is dangerous, so long as it is taken for granted that the pattern is right without a full understanding why. It leads to those thoughtless methods of designing machinery by empirical rules and formulas, by proportional scales, by units—methods almost universally practiced and taught in our colleges as "machine design" to such an extent as to make machine designing appear a mere matter of routine. The designer must look at every perfect piece of machinery as suitably shaped and proportioned in that one and particular case alone, and must determine by careful consideration and investigation whether it is admissible to just multiply the dimensions of any piece by a factor to make it fit another case, even though a similar one. We shall in due time revert to this matter, and indicate the limits within which the methods characterized above are useful and justifiable.

Existing designs cannot rightly serve except as examples or suggestions, but familiarity with them *as such* (and the more of them the better) constitutes the practical experience of the designer—part of his stock in trade, so to speak. It is evident that the machinist-draftsman has had more opportunities to gain such experience than the college graduate, but if he has grafted on his memory existing forms, dimensions and combinations, without regard to the prevailing circumstances and conditions, this experience will avail him little; he must be able to sift all this material, and to do this he must have theoretical knowledge of the underlying principles. The college graduate, with this requisite knowledge at his command, has thus a decided advantage; *his* difficulty will be to accumulate practical experience; he will have to concentrate his energies on observation and on the analyzing of existing designs, while the machinist-draftsman will first of all have to sit down and study. The road is as hard for the one as for the other.

(*To be Continued.*)

IN THE WORKSHOP.

(*Continued from the June, 1899, Number.*)

H. Rolfe.

FITTING IN TAPER PINS—OVERDRIVING THEM—JUDGMENT IN MAKING PRESS FITS—FORCING IN SIDE-ROD AND OTHER BUSHES—THE NERVOUS WORKMAN.

ONCE upon a time a gentleman named Robert Bruce had a little family quarrel, the other party to the dispute rejoicing in the name of the "Red Comyn." In those days, when men fought to kill time—and each other—quarrels were plentiful, there being nothing much else to do; and these little bickerings generally ended disastrously for all concerned. The quarrel in question came to a crisis in a church, of all places, Bruce exercising himself on his relative with a sword. On coming out of the edifice, he naturally looked a little perturbed (though it took a good deal of this sort of thing to upset a man's equanimity in those days), and a friend asking him what was amiss, he replied, "I doubt that I have slain the Red Comyn." "Well," replied his friend, "I'll mak sicker." And forthwith he rushed in and, with the aid of a businesslike dagger, put the matter beyond all doubt.

The writer read this story thirty years ago, but remembers it distinctly now, the pains that the third party took to *make sure*, being rather striking—literally so for the Red Comyn. Now, there is a lot of this "making sure" at the present day in the

iron trades, in both shop and office. We will take the latter first, choosing a detail, and a small one at that, to begin with, namely, the motion pins of a locomotive engine. In American practice the eccentric rods and rocker-pins are in reality bolts, with heads and nuts as ordinarily. In Europe it is customary to support the link by hangers on either side; not only so, but

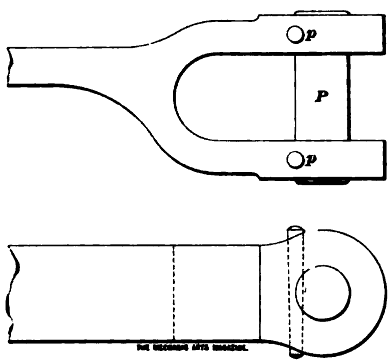


FIG. 1.

the valve-stem centers are brought pretty close together, so as to get larger cylinders in. Now, this necessitates a *set* in the valve-stem guide, and to keep down this set the eccentric rods are made practically flush with the eccentric-rod jaw, as shown in Fig. 1, the link-block pin being also flush with the jaw of the valve-spindle guide; thus the hangers can be set closer in and the links kept closer together. The pin P is "lapped" in, and the holes p drilled and reamed in place, the hole being halved between the pin and the eye. Now, if the pins p are fitted in properly, there need be no fear of their coming out; on the contrary, they are one of the most troublesome things to *get* out when stripping an engine. The very slight taper that they have has much to do with this, and also the fact that nervous engineers (who, not being mechanics, cannot be expected to know how tight to make such things) often knock these pins down with a coal pick, "to make sure." It would be fair retribution to make these men knock them out again. But we shall allude to this later.

Engine runners are not the only transgressors in the matter of overcaution. The designer, who, we will assume, has had no shop experience of any real value (as is the case with the majority), not knowing the holding power and reliability of a properly fitted taper pin, goes a step further and makes it a split one also. Now, taper split pins are all right for crank-pin washers, for we know that crank-pins undergo constant shocks, great and small, to say nothing of their swinging around in a 2-foot circle from five to six times a second. And here comes in another point, seemingly insignificant and often neglected; we allude to pressing the crank-pins in so that in revolving, the small end of the taper pin shall lead, arranging them as in Fig. 2, and not as in Fig. 3. In Fig. 2, centrifugal force is all the time tending to *tighten* the pin; in Fig. 3, it is tending to *loosen* it—to throw it out. Now, the effect may be slight, but we hold strongly to the following maxim: Where there are two courses open to the designer, the one a little more advantageous than the other, choose that one, no matter *how* small its advantage may be. In the present case, for instance, we have a certain amount of centrifugal force due to the weight and motion of the pin, and we can arrange things so that this force tends either to loosen the pin or to tighten it; we ought to immediately choose the latter, even though the advantage be but microscopic, and note the drawing to that effect. We contend that this seizing and making use of small advantages that already exist and are not of our own making, should be encouraged, and by no means classed with those efforts "to make sure," which are the offspring of nervousness and ignorance. In the majority of cases, the taper pin is set at right angles

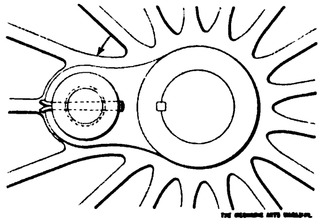


FIG. 2.

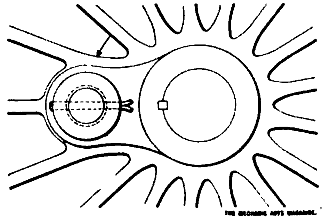


FIG. 3.

to the crank; we will not now discuss this point, merely remarking that we prefer the arrangement shown in Fig. 2.

As an illustration of overdoing a thing, we quote a case where the designer was evidently impressed with the value of "draft" in keying up; he, forsooth, went to work and put draft on a taper pin. He knew it was

necessary to keep the pin fast in the jaw, so he made his drawing as in Fig. 4. As to how the draft would be put in, in the shop, he neither knew nor cared—perhaps thought they would *file* it. We don't know how they *did* it (extremely probable they *forgot* to do it), but should think the only way would be to fit the pin in the usual manner and afterwards use a safe-back reamer of section shown at *R*, and thus

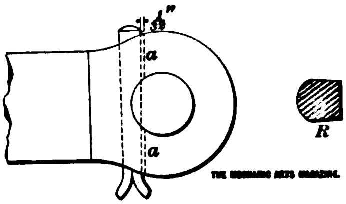


Fig. 4.

work out the metal as called for. This design struck the writer as being a very amusing refinement. The designer evidently had in mind that if the pin got loose, this draft would enable the engineer to tighten it up again, but he defeated his own ends to a great extent, for removing the metal at *a* and *a* relieves the pressure on opposite parts of the pin, and thus less holding power is obtained than if the pin were "solid" throughout its depth.

It has been said above that engine runners sometimes drive these pins in too tight; that is one of the things that shopmen have to put up with. When stripping an engine, the writer has often found it impossible to get these taper pins out, especially when split—in which case there is nothing solid to hit at; and when they are solid, the more you hammer them the more you upset the end, which makes matters worse. Often, after ruining every punch we could beg, borrow, or steal, we have at last had to get a flogging hammer and drive the motion pin itself out bodily through the jaw, shearing off both taper pins. We can see the look of horror on some of our readers' faces at the mention of such sacrilege; but if they had been in a rushing shop, where one fitter had not only to get an engine ready for lifting, but strip her entirely, and no excuse taken for being long about it, they would have done as we did; if anything got sprung or bent—well, that was left to the bench fitters, whose duty it was to send things back ready to go up.

Speaking of driving in the pins too tight brings us to that part of the fitter's professional equipment which may be called *sense of touch;* this comes to one in time. A taper pin, properly fitted, needs but little driving home. There is no need to swing your hammer over your shoulder until it reaches the small of your back; a 4-inch lift will do. It is hard to tell in words just how to drive these pins, and it may seem a small matter at most, but erecting-shop and roundhouse men will appreciate the spirit in which these remarks are made—*they* have to get the pins out again.

The sense of *feeling*—the ability to judge how tight to make a certain detail—is constantly being called into requisition, in keying up crossheads, for instance. Who has not seen the green hand banging away at a cotter for all he was worth long after the thing had been drawn up solid? He is putting a new end on a piston rod, and is keying it up on the bench; the rod is designed to bottom in the crosshead, as it *ought* to. Now, a man who is not altogether without the making of a machinist can discriminate at once between the resistance due to the conical fit and that offered when the rod is "home." There is a solid feel about it in the latter case that there should be no mistaking—unless the man has mistaken his vocation. The writer once derived not a little amusement from watching a brawny apprentice (in his last year, too) using his lead maul with more strength than discretion. After about a dozen "try-ons" the rod at last bottomed, but he knew it not, and when he knocked his cotter out it was somewhat as in Fig. 5; the joke of it was he could not make out the cause. It is easy to get a cotter ⅛ inch hollow this way.

There are many other cases where accurate sense of touch is required—in knocking down axle brasses, for instance. The old style of octagonal brasses, in which both brass and box were fitted up out of the black, is out of date; instead, the box is bored out and the brass turned up and pressed in sideways, by air or hydraulic pressure. As regards saving of time and expense, and getting a better job, this is, in our opinion, one of the greatest improvements ever made in locomotive construction, provided the lower edges of the brass are cut at an angle to keep it from closing in under wear and pressure. Sometimes the brass is cast solid in the box, or rather, to be exact, the box is cast around the brass; it then has flanges, and when the brass is worn out the box is broken up and melted. The writer at one time worked in a shop where this style of box was used, and

Fig. 5.

remembers being puzzled for a minute as to how the thing was got in—somewhat as King George III was over the apple in the dumpling.

A misplaced and thoughtless exertion of brute force is often seen, too, in putting in side-rod bushes. It is astonishing how some men, good workmen, too, seem to lack judgment in this matter. Simply another instance of following up an idea too far—of overdoing it, in fact. They think that because a bush requires to be tight, the tighter it is the better. Now, a bush *can* but be tight; after that is reached you are merely going to close the bush in or else spring the eye. Anyway, we opine that many a rod has failed in the eye, owing to the bush being put in too tight. The only thing to do is to put them in in a press, and if they show signs of acquiring much more than the legitimate pressure (10 tons is ample) take them out again. We have seen bushes put in, under the screw press, dangerously tight; the workman gets the bush in about three-fourths of the way and then rather than take it out again "makes her go"—putting quite a strain on the rod end (an especially undesirable thing if the latter has been case-hardened) and closing his bush in so that he has less play in the pin than he allowed for. Sometimes these rod ends wear a little large one way, especially where there has been a loose bush. Then, instead of boring it out, or lapping it, if hardened, or filing up the brass, he simply puts the latter in as turned, and relies on an extra-tight fit to make the bush fill the hole.

In regard to fitting operations, putting brasses in axle boxes, fitting in piston-rod ends, main- and side-rod brasses, etc., it is interesting to note how the temperaments of different men assert themselves. Take two men, B and C, for instance: B makes all his gauges "full," for the planer or shaper; he hasn't enough confidence in himself, can't trust his calipers—likes to "make sure" that he will have enough stuff to work on, so he leaves his gauge full; if he is doing his own machine work, as is sometimes the case in small shops, he is equally cautious. The result is, he has a terrible lot of filing to do. C, on the other hand, works pretty close to size, especially if he knows his man. If he is doing his own machining, he works equally close, the result being that he can take his big-end brass, say, out of the machine and shove it half way down the strap first time. B has to do a lot of filing on the flanges and two faces before the thing will enter at all. Or, again, suppose the piston rod has been reended and is being turned up ready for fitting in the crosshead. B will leave his too big, and it won't go home at the first driving within $\frac{3}{8}$ inch. C will get his taper carefully, noting whether his crosshead fit is at all hollow, and then go ahead, and when done will drive the crosshead within $\frac{1}{8}$ inch of home the first time. We do not recommend having much less than $\frac{1}{8}$ inch at the first driving; we should leave this much for getting a good bearing and for pulling up with the cotter. (We are not dealing with "ground fits" just now.)

Even if you start the two men on equal terms, C will "try on" only about half as often as B, with the result that his axle brass (if that is the job) will be a tighter fit when finished, for most of the trying on is done when the brass is nearly home, and every time the brass is knocked in and out the slacker it gets on the gripping faces, and by the time B has got his brass bedded down, the holding power is nearly gone—perhaps entirely—in which case he puts packing between the collar and the brass and lets it go; he knows it will hold while being bored out, and for the rest he doesn't care so long as the erector passes it; but all the same, that brass will be knocking in the box before a couple of weeks have passed. B, again, if fitting in a new reversing-piston bush in a Westinghouse air pump (repair work) will knock it in many more times than C would, who in this, as with other details, sees at an early stage just how he stands, and goes ahead accordingly. If, in addition, B has no sense of touch, he will drive away too hard and end by jarring the bottom of the bush off, or, like as not, will leave the bush so tight that it closes in at the top, where the taper fit is, and thus makes the pump slow to get away from the bottom of the stroke. Or, if pressing in a new reversing-valve bush, he will be afraid to work to his calipers, and so "to make sure" of its not being slack, will leave it too big and perhaps end by cracking his cover, if not warned in time, which he won't be, as we are assuming him to be devoid of that sixth sense that tells you how much work you can put on to an object of given form and material. Or, his lack of confidence may assert itself differently, and being afraid to put the bush in tight enough (to insure the proper steam fit) will get it too slack, and so when it is put on the test rack he will find that he has to knock it out again and put in another.

This matter of courage in the shop is an

interesting point. It is altogether different from moral or physical courage, as understood in every-day life. Sometimes a little atom of a man, who is frightened at his own shadow, outside on the street, corresponds to our imaginary friend C, while, on the other hand, the terror of the neighborhood may be our friend B—a man who will shake in his shoes if put on a strange machine, or a new job, or set to strip and lift an engine by himself. Such men can work all right under another man's direction; they are generally good workmen, so far as mere manipulation of tools goes, but if they are put on a fresh job, only slightly different from what they have been used to, they get rattled. The other class, however, are often indifferent vise hands, but no job comes amiss to them—laying out, templet making, machine and engine breakdowns and repairs of all kinds, millwrighting, etc. In short, they don't *like* to stick on the same job year after year; they prefer variety, something strange and new every time. These men are exactly the ones to make foremen of; the man who is merely a good bench hand is no good for foreman. Get him used to a job and then keep him there for the rest of his life. He will give good satisfaction—ten times as much as the other man would—and you will get both speed and quality out of him. In fact, it would be rather a pity to waste a good workman like that by making a foreman of him; he would not be so happy, either.

(To be Continued.)

HOW SHOULD KEYS BE FITTED?

Carl G. Barth.

SHOULD A KEY BE FITTED TOP AND BOTTOM, ON THE SIDES ONLY, OR ALL AROUND?—THE BEST SHAPE FOR A KEY.

WHAT a simple, every-day job it seems to the machinist, who has been brought up a certain way in a certain shop, to fit and drive a key properly. Of course the machinist knows all about it; and he is not likely to take kindly to anybody who may happen to suggest that there is another way of doing it besides his, particularly if that new *busybody* should venture to claim any advantage for that other way. If, however, our friend gets around a bit among other shops, he finds that there is not only *one* way, but a *number* of ways, besides his, or rather, besides that of the shop in which he served his time. He will also discover, probably to his surprise, that there are few subjects in mechanics in regard to which opinions differ so much and so widely. And, further, these differences of opinion exist not only among machinists, but to a still greater extent among machine designers and engineers, who frequently get into heated arguments about the matter.

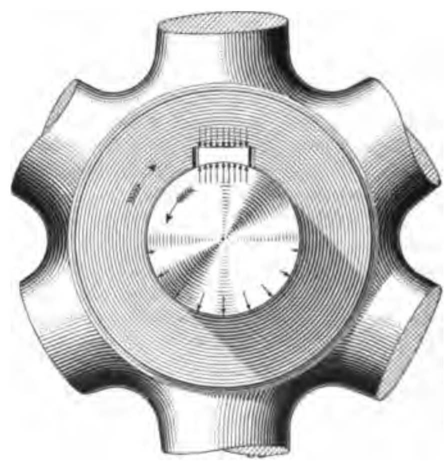


FIG. 1.

The questions about which the discussions generally arise are as follows: (1) Is a *square* key better than a *shallow* key? (2) Should a key be fitted top and bottom only, or on the sides only, or top and bottom as well as on the sides?

Let us see whether, by a careful and unbiased consideration of the most common forms of keys and the various ways of fitting them, we can gain some insight into the manner in which a key performs its function as a driving link between the shaft and the hub that it drives, or by which it is driven. A little thought will then enable us to defend our present practice, if it is good, and we shall feel no hesitation in giving up our old ideas on the subject when they are shown to be wrong.

In connection with all the accompanying illustrations, we will suppose the shaft to

drive the hub in the direction indicated by the inside arrow, or the hub to drive the shaft in the direction of the outside arrow, these two different suppositions being in every case identical as regards the action on the key.

In Fig. 1 is shown the *saddle*, or *concave*, key. This appears to be the only form about which opinions do not differ, as it evidently drives merely by the friction that it gives rise to between the surfaces of the shaft and the hub. For this reason its driving power is very limited, and it is accordingly made use of only in cases where adjustments between the hub and the shaft have to be made after the erection of the machine, and when, at the same time, the slipping tendency is but a small fraction of the twisting strength of the shaft. There would evidently be no advantage in having this key fit tightly on the sides, so far as driving power is concerned; for, if the friction between it and the shaft is sufficient to prevent slipping on the curved surface, the friction would also be sufficient to prevent slipping at the top surface of the key on its seat in the hub. The thickness of this form of key is evidently of no consequence, and therefore it is a matter of taste and convenience only.

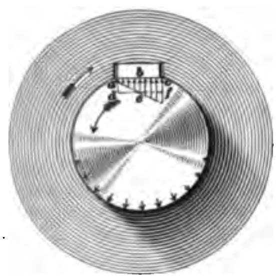


FIG. 2.

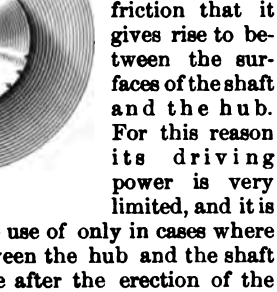


FIG. 3.

Fig. 2 shows the *flat* key. Though the driving power of this form of key is greatly increased by the friction due to the pressure between the surfaces of the shaft and the hub, we will, for the sake of argument, neglect this and consider only its *direct* driving power.

Suppose, then, that the shaft drives the hub in the direction indicated. It will be seen that points on the flat *a b c* of the shaft, to the right of the center *b*, will be thrust hard against the key; whereas, points to the left will tend to move away from the same, the result being a redistribution of the pressure between the shaft and the key, and consequently, also, between the key and the hub. Its intensity will be lowered to a minimum at the extreme left-hand corner *a*, and raised to a maximum at the extreme right-hand corner *c*, the original intensity of pressure being retained at the center point *b* only. This has been indicated in the figure by the vertical arrows, whose lengths are intended to represent the intensity of the pressure at the different points; the straight line *d e f* similarly represents the original, uniform intensity of the pressure that is due to the tight driving in of the key.

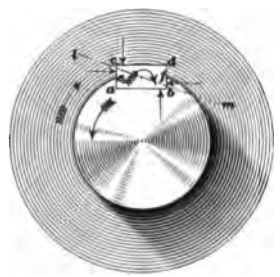


FIG. 4.

It is evident that the effectiveness of this form of key will increase rapidly with its width, and that it is independent of the thickness of the key. Very little thought will also convince one that nothing is gained by making it a tight fit sidewise in the hub.

Referring now to Fig. 3, we recognize at once that a *sunk* key which does not fit on the sides, but is a driving fit between the top and bottom only, must, in every way, act as the flat key just considered.

If, however, the sunk key also fits tightly on the sides, as illustrated in Fig. 4, the conditions become entirely different, and, as a consequence, the driving power of the key is enormously increased. In this case, the key will, in the first place, receive the greatest pressure from the shaft along the shallow surface *b f*, and from the hub along the shallow surface *c e*. But these surfaces and pressures, not being directly opposite to each other, the latter will tend to turn the key around in its seat in the direction indicated by the arrow. This tendency thus thrusts the corner *b* harder down against the shaft, and the

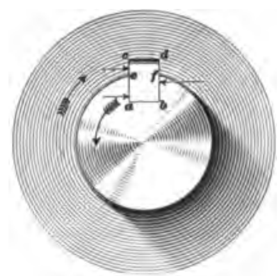


FIG. 5.

corner c harder up against the hub, until the combined effect of the pressures on both sides of the corner b will be directly opposed to the combined effect of the pressures on both sides of the corner c, along some line $l\,m$ through the center of the key.

The action is such that it makes little difference whether the key is, in the first place, driven in very tight or not, so long as it is perfectly home against all the faces surrounding it; but it is of advantage to make the width of the key greater than its depth, in order that it may not have to turn around too much to bring its corners b and c to bear sufficiently hard against its bottom and top seats, respectively. If it is made narrow, the consequence of this turning action will be too much concentration of the pressure towards the corners b and c of the key, and towards the corners e of the hub and f of the shaft.

In order to better understand the action of a key sunk half into the shaft and half into the hub, but fitted sidewise only, we will first consider the feather key, Fig. 5. It is supposed to be tight in the shaft only, and to be quite free, even sidewise, in the hub. Driving as indicated, it receives the pressure of the hub along the face $c\,e$. This pressure will then act upon the key as a prying lever, thrusting it hard against the side $b\,f$, in the neighborhood of f, and hard against the side $a\,e$, in the neighborhood of a; and it is obvious that the intensity of the pressures produced at the points f and a will be less the deeper the key is sunk into the shaft, and the less it extends into the hub.

FIG. 6.

Turning now to Fig. 6, which represents the square key not fitted tightly top and bottom, but sidewise only, we recognize a similarity between the action of the *shearing stress* through the middle section $e\,f$ of this key upon each embedded half, and the action of the pressure of the hub on the key shown in Fig. 5.

Considering first the upper half, we see that this shearing stress, extending, as it does, in the direction f to e, will thrust the key hard against the side $c\,e$ of the hub, in the neighborhood of e, and against the side $d\,f$, in the neighborhood of d. It thus exerts, on account of the short depth of the key, an intense prying action in the hub. In precisely the same manner, the shearing stress, which extends in the direction from e to f, will thrust the key hard against the side $b\,f$ of the shaft, in the neighborhood of f, and against the side $a\,e$, in the neighborhood of a, and will thus exert a corresponding and equal prying action in the shaft.

Evidently, then, this is not the way to fit a key, and we are forced to conclude that the ordinary sunk key must be fitted tight all around, as in Fig. 4, in order to serve its purpose in the most efficient manner; and also, that its width ought somewhat to exceed its depth.

I WONDER.

THE story is told that as a prominent politician walked along the street one day, in the company of a friend, he noticed a member of the opposition passing along the other side, with measured tread and head bent down, to all appearances wrapt in the deepest meditation. "Ah!" said he, "White looks as though he were thinking, doesn't he? But he isn't; he's only wondering."

This was no doubt intended as sarcasm, though it is possible it was also true, for this wondering instead of thinking is a very common habit, and a very bad habit too. How often we hear people say, "I wonder;" "I wonder so and so;" "I wonder how such and such a thing is made or done;" "I wonder why such a thing is so." The very word *wonderful* is evidence of our prevailing weakness. A thing is wonderful, because it fills us with wonder. Wondering is all very well in its way, but it should lead to *finding out*, otherwise it is a waste of time. It would be a good thing for all of us if every time we said "I wonder," we were to add "and I will try to find out."

TAKING PORTRAITS INDOORS.

Louis Allen Osborne.

STUDY OF THE SUBJECT—ARRANGEMENT OF LIGHT—HOW TO FIT UP A HOME GALLERY. EXPOSURE AND DEVELOPMENT.

IN PHOTOGRAPHY, one of the most difficult problems that confronts both the amateur and the professional is portraiture. Few possessors of a camera realize this fact sufficiently to take the trouble to study the subject scientifically, yet few of them leave it entirely alone. The old idea that a photograph cannot lie is a false one, as any portrait taken under improper lighting facilities will prove.

Now, if we are to make photographic portraits, we must consider a few facts outside of photographic chemistry. If the portrait is intended to be a good likeness in the opinion of the model, then we must bear in mind that the only way that a man gets any personal idea of his own appearance is by looking into a mirror, and that therefore he usually sees himself either full-face or three-quarter full-face. If a person has a fine profile, it is sometimes advisable to make a profile portrait, because the possessor of a striking profile soon learns the fact and will in some way contrive, by a combination of mirrors, to get a side view of himself. On the other hand, we must endeavor to as far as possible hide the natural defects of feature that our subject may possess, because, through custom and association, these defects seldom appear as bad to their possessor or his family as to the comparative stranger or outsider. For instance, a person with a snub nose never realizes its enormity until by accident or design he gets a view of his profile. We must be careful, therefore, when making a portrait, that we do not render these defects too apparent; it is not only necessary to avoid making them worse than they really are, but we must endeavor to avoid making them any worse than our subject *thinks* they are.

FIG. 1.

Some phases of human nature may be studied to more advantage in portrait photography than in any other profession, and the more observant the operator is of details of character and disposition, the more successful he will be in taking portraits. The details are matters of first importance, and unless due attention is paid to them, other considerations will be of little value.

It is by properly "lighting" the subject that strongly marked characteristics are emphasized and defects of feature subdued. Upon the strength, depth, and direction of the light depend nearly all the characteristics of the finished picture.

It certainly should not be necessary to tell the reader that a portrait should never be taken in full sunshine, yet there are many misguided amateurs who endeavor to accomplish this very thing. When taking a portrait, lots of light is required, and strong light; but *never* full sunshine on the subject.

Indoor portraiture, which is all we will discuss at present, requires a much longer exposure than open-air portraiture, the intensity of the light being much less; but with the arrangement of screens and reflectors herein described, a well-lighted indoor portrait may be made with an exposure of

four seconds, that would require four times as long without reflectors, and would even then be poorly lighted.

In all professional photograph galleries we find the sitter illuminated from a skylight. It is therefore reasonable to assume that the best results are obtained when the light comes from above the subject. In the gallery we also find several white or gray screens that the operator moves about into various positions, to reflect the light on the side of the subject so as to get just the character of illumination he desires.

In our arrangements to make portraits at home, then, it will be best to follow as far as possible the methods used in the regularly equipped galleries. Skylight we do not possess, but we can soon, and with very little trouble, provide a substitute that is very

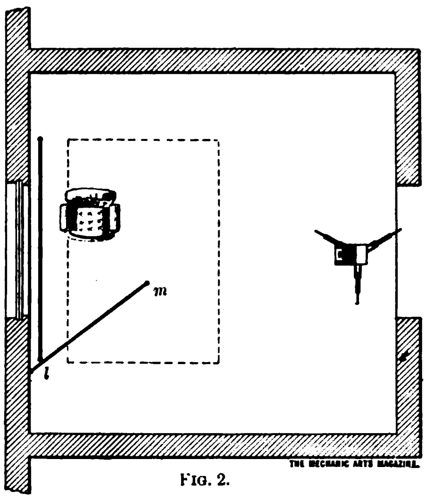


FIG. 2.

nearly as good. In Fig. 2 is shown the plan of a room about 12 feet square, with a window on one side; this room we propose to arrange as our gallery. If possible, the window should face the north; if not, the room should be used for photographic purposes at such times only as the sun does not shine in at the window.

The window should be covered with some opaque material to a height of about 5 feet from the floor, or to the meeting rails of the sash. Heavy, rough, bookbinders' board is excellent for the purpose, as it can readily be cut to exactly fit the space. Over the lower part of this window, and against this opaque covering, should be hung some fabric to form the background; its color should be varied according to the character of the subject to be photographed. Dark subjects call for a light background, and vice versa, though an absolutely black or white background is seldom used.

A most excellent material for a background is ordinary cambric or silesia, of a drab color. This should be moistened by sprinkling, and then stretched on a frame about 5 or 6 feet square. If it is necessary to sew together two or more strips in order to get the required size, this will make no difference, as the seams will not show in the picture unless the background is brought into focus, and this it should not be, unless a regular professional background is used.

Across the ceiling, about 18 inches in front of the window, an ordinary linen sheet or other white fabric should be hung, and after its top edge has been secured to the ceiling, its lower edge should be stiffened by means of a strip of wood, and the whole maintained at an angle of about 45° with the light entering the window. Under this white reflector, and in front of the background, the sitter is to be posed, as shown in Fig. 3, where *a b* is a section through the wall of the building, showing the window at *c d*. At *e f* is the background, about 6 feet high; *g h* is the reflecting screen, at an angle of 45° with *a b*. The bottom edge of screen *g h* should be low enough to hide the top of the background when observed in the camera *k*. A plan view of this arrangement is shown in Fig. 2; in this, *l m* is another reflector of white cloth or paper, so hung as to illuminate the face of the sitter and cut down the contrasts on the lower portions of the head and shoulders.

Now let us for a moment consider the effect of all this. The light enters through the upper half of the window, between *c* and *e*, strikes the screen *g h*, and is then reflected down on top of the sitter, *precisely as though it came through a skylight.* The bottom edge of the screen can, if desired, be lowered slightly, so as to throw the light more against the side of the sitter; or it may be raised, so as to deepen the shadows on the side nearest the camera. The screen *l m*, Figs. 2 and 4, can also be adjusted to get any desired lighting effect, and thus the amateur has the means of producing some of the most artistic effects obtainable with a camera.

To make a full-face portrait, the sitter should be posed about 2 feet in front of the background, and the reflector *g h* set so that the shadow of the nose falls on the upper lip; then the side screen should be set so that one side of the face is illuminated a trifle more than the other. It is seldom desirable that an absolutely full-face picture be taken;

therefore, after these arrangements have been completed, it is well to have the sitter turn the head slightly, so as to show a little more of the lighted side. This will produce a picture lighted as shown in Fig. 5, while the turning of the head *towards* the light will show more of the dark side of the face, and the result will be a picture lighted as in Fig. 1. To produce the condition of lighting shown in Fig. 1, the screen gh is so adjusted as to throw the light nearly perpendicularly upon the figure, and the side screen is so placed as to strongly light the face on the side away from the camera. This gives a sharp, clear outline to the profile, while the rest of the face remains in comparative shadow.

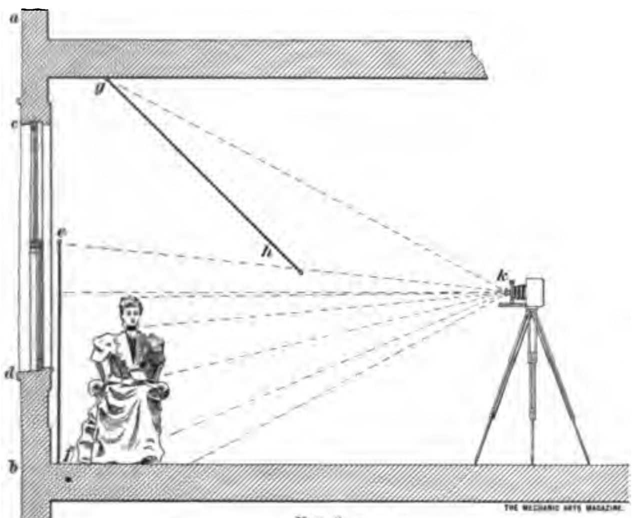


FIG. 3.

Where the photograph is to be a full-length figure or a three-quarters full length, care must be exercised that the upper part of the subject is not more strongly lighted than the draperies nearer the floor. It is well, on this account, to spread on the floor a white sheet or a number of newspapers, so that the light may be reflected upward against the lower part of the figure. Fig. 6 shows a subject posed to light the face as described for Fig. 5, while the lower part of the dress was at the same time strongly illuminated by reflected light from a sheet spread in front of the camera about 20 inches from the feet of the subject.

Where a person has light curly or fluffy hair, it is best to illuminate the hair brilliantly by setting the top screen about as shown in Fig. 3, and then arranging the side screen to reflect light on the face in an *upward* direction, so that as far as possible its stronger shadows may be softened and too much contrast prevented.

A little practice will enable the amateur to produce any kind of lighting desirable, to suit any particular style and character of subject to be reproduced.

Now let us consider the exposure of the plate, and the development of the negative. In the first place, only the fastest of plates should be used for indoor portrait work. Among the most common brands are the Cramer Crown, Eastman Red Label and Film, Seed 27, and Stanley 50. The Hammer Extra Fast is also a good plate, but it is not quite as rapid as the others named.

The camera should be near enough to the sitter to have a good-sized picture on the ground glass, but not so near as to produce a distorted picture. On a $4'' \times 5''$ plate the person's head should never be taken larger than one-sixth life size; nor should the camera be set nearer than 8 feet from the subject. The lens should always be worked at full opening, even though in consequence some details do not focus clearly. The camera should be placed in front of the background, as explained, and then focused upon the eyes of the subject. If the mouth and chin do not come out clearly, the swingback of the camera may be tilted slightly, so as to bring these details into focus. If the camera has no swingback, it is advisable to move it farther away from the sitter, and focus the image smaller. The back part of the head and the ear—if the latter shows—may also be out of focus, but this will do no harm so long as the ear does not thereby appear unnaturally large. Should the latter

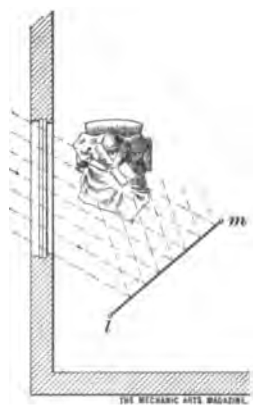


FIG. 4.

be the case, it will be wise to arrange the hair to cover the ear (as was done in Fig. 5) or to change the position of the head slightly, so as to render the ear less prominent.

The question of exposure is a difficult one to deal with. So many conditions of light, background, etc. enter into the determination, that no positive rules can be laid down; but in all cases of portraiture, the operator should be sure to give exposure *enough*. A very little practice will go a long way towards perfecting the judgment, and the operator cannot go far wrong if he goes by the following rules: If the window from which the light is taken faces north, give an exposure on a clear day, between 10 A. M. and 3 P. M., of 4 seconds; this is for the summer time, and where the room is in the second story, or, if on the ground floor, where there are no trees or houses nearby to obstruct the clear light from the sky.

In winter, under the same conditions, give 6 seconds.

If the window faces east or west, and the sun is shining on that side of the house, but not in at the window, give 3 seconds in summer and 5 in winter.

If the window faces east or west, and the sun is on the side of the house *away* from the window, give 8 seconds in summer and 10 in winter.

These exposures are based on the conditions of background, and color of materials heretofore described; if the sitter is wearing a white or a pale-blue dress, the exposure should be reduced about one-sixth or one-quarter; if the dress is black or red, the exposure should be correspondingly increased.

Fig. 5.

Fig. 6.

If the background is black, and a clear, well-defined outline is desired against it, the exposure may be shortened a trifle, say one-sixth; and if the background is dead white, the exposure should be correspondingly lengthened. This decrease for a dark background and increase for a light one may at first appear somewhat unusual, but when it is desired to get strong contrasts, the exposure must be short; long exposures tend to decrease the high lights and to render white surfaces less glaring.

With indoor work of the kind we are discussing, exposure is not a matter of as much difficulty as it is with outdoor photography, for the reason that the amateur, making portraits by the same window and under the same lighting conditions day after day, soon becomes as accustomed to the "timing of conditions" as does the professional photographer in his gallery. A few trials will determine the proper exposure, and after that serious errors should be of rare occurrence.

The next consideration is that of development; though many are of the impression

that so long as the exposure has been correct, development is *easy*, such is far from being the case in portrait work. Overdevelopment of a correctly-timed negative will destroy the lighting effects, and underdevelopment will give flatness and lack of detail.

The developer should be stronger than for ordinary landscape work, but not so strong as for snapshots, and should contain just sufficient bromide of potassium to make it work clear. Pyrogallic acid makes not only the best developer for portrait work, but is also the easiest to prepare. The following simple formula is recommended, as it gives excellent results and, being in two solutions, can be varied slightly, to suit different conditions. The proper working strength, however, is the one given, and variations should be made only to suit certain special conditions, as explained below.

A	Pyrogallic acid	1 oz.
	Sulphite soda (crystals)	4 oz.
	Water (pure)	16 oz.
B	Sal soda	4 oz.
	Water	16 oz.

To develop, take 1 ounce of *A*, 1 ounce of *B*, and 8 ounces of water, to which may be added 6 drops of a 10-per-cent. solution of potassium bromide. If granulated sulphite of soda is used, only half the above quantity of this chemical will be needed.

Place the exposed plate in a suitable tray, pour sufficient developer over it to cover its surface, and rock the tray slowly until the development is complete. The image should appear slowly, and gather density gradually; the development should be continued until the high lights are fairly dense, not so dense, however, but that the detail is still observable. When fully developed, pour off the developer, rinse the plate, and fix it in hypo as usual. Throw away the developer after once using it, as good results cannot be obtained from old solution, and the stock is too cheap to try to economize by using it twice. The above quantity of stock-solution developer should cost but 22 cents, and is sufficient to develop 44 plates of the smaller sizes, at a cost of ½ cent each.

Some kinds of printing papers require negatives of strong contrast, while others give better results with a weak negative. To produce the former characteristic, it is simply necessary to increase the proportion of solution *A* to 1½ ounces, and to add more bromide; softness and detail may be gained by increasing the proportion of solution *B* to 1½ ounces, and making the developer up with 10 ounces of water instead of 8. It is an excellent plan to make three exposures of the same subject on three different plates, and develop them with the three forms of developing solution above mentioned. The inexperienced amateur can then get a very fair idea of which is best suited to the conditions he seeks in his own case, and can govern himself accordingly in future operations.

Very satisfactory results are obtained with any of the gas-light printing papers, when a moderately thin negative is used, but for printing in platinum and carbon a little more contrast is desirable.

Glossy paper will require deeper printing than mat surface, as the latter appears darker when dry than when in the baths. It is always well to bear this fact in mind, especially in portrait work, as the depth to which a picture is printed materially affects the character of the finish. Only in the rarest cases is absolute black and white desirable in a portrait. Even where the draperies are in reality pure white, it is generally desirable to print the white parts of the picture deep enough to cause them to assume one tint darker than a pure white.

Bromide of potassium added to the developer of gas-light papers will tend to increase the contrasts, but in making prints by daylight these effects are obtainable to the best advantage by the proper treatment of the negative in development.

Never make blueprints of portraits. The color is not only most unsatisfactory for such a purpose, but the peculiarity of the paper renders it almost impossible to secure satisfactory detail.

A portrait must be a good likeness and a technically perfect photograph or it is useless, its defects always standing out more prominently than in any other class of picture. Therefore, do not try to get perfect results with improper papers or accessories.

After the negative is fixed, washed, and dried, a proof should be taken to determine how much, if any, retouching is required. Nearly all portraits require some retouching, the details of each feature being not always perfectly satisfactory as they are first impressed on the plate. Retouching is an art in itself, and should be done by a professional retoucher, until the amateur has progressed sufficiently in his lighting, exposing, and development of portrait subjects to be able to devote nearly all of his time and patience to the study of retouching. Learn to make perfect negatives first.

THE LEGISLATOR OF THE STARS.

George McC. Robson, M. A.

Fruitful Fancies—Astrology and Sorcery—The Laws of the Solar System—Kepler's Speculations on Gravity.

"Do not the hist'ries of all ages
Relate miraculous pressages
Of strange turns in the world's affairs
Foreseen by astrologers, soothsayers,
Chaldeans, learned Genethliacs
And some that have writ Almanacs."
—*Hudibras.*

England produces neither gold nor precious stones, yet her treasure houses are overflowing with wealth; her damp flat fields and dull skies afford little inspiration for poetic or artistic fancy, yet her galleries are crowded with the noblest creations of art and her youth are nurtured on the poetry of Homer and of Dante. As England has gathered her material and artistic treasures from the east and from the west, so also has she enriched her language with the choicest words of all languages. In her vocabulary we find, side by side, the words that served the subtle Greeks in their deepest philosophy and the words in which the Romans proclaimed the laws that governed the world. In such a language it is both interesting and instructive to trace the pedigree and descent of words, and to note their relationships and intermarriages; in this way alone can a clear conception of their finer shades of meaning be gained.

By studying the derivation and history of the word *astronomer* one gains a broader conception of the science of astronomy, and encounters some very surprising relationships. The word *astronomy* is derived from the Greek words *astron*, "star," and *nomos*, "law," and therefore astronomy is the science of the laws that govern the stars. But if we follow the pedigree one step further, we find that the Greek word *nomos* is derived from the Greek verb *nemein*, which means "to tend as a shepherd tends his flock"; in the light of this derivation, an *astronomer* is a "shepherd of the stars." It is interesting to compare the derivation of *astronomy* with that of the closely related word economy. The word *economy* is from the Greek words *oikos*, "house," and *nemein*, and therefore an economist is "the shepherd of a household."

The derivation of the word astronomer, as we have traced it, suggests that there are two distinct types of astronomers, whose functions are entirely different but which are both necessary to the progress of the science. There must be astronomers that are careful and accurate observers of celestial phenomena—men of clear eye and skilful hand—who do their patient and laborious work under the cold clear midnight skies of winter, and who fit out costly expeditions to distant lands to observe phenomena that are not visible from their fixed observatories. There must also be astronomers that possess great intellectual powers to explain the import and mutual relations of the observed facts. Nor is astronomy singular in this respect; for any science, the two things that are essential are facts and ideas, and the development of any science needs clear vision and deep thought. Science is the interpretation of nature, and therefore needs both the interpreting mind and nature for its subject. Science advances when clear, acute, logical thought is applied to accurately known and clearly conceived facts. That subtlety of intellect alone cannot create science is shown by the failure of the Greek schools of philosophy, with all their perfection of demonstration and method, to make any advance in physical science. Nor does the mere observation and knowledge of facts constitute science; and the Red Indian, of whose powers as an observer of nature Fenimore Cooper is such an enthusiastic admirer, made as little progress in science as the Greek philosophers or the schoolmen of medieval Europe. Since science, then, can be advanced only by clear ideas grappling with distinct facts, it is evident that every physical science demands the services of skilful observers and profound thinkers.

Occasionally there is a man so gifted that he renders distinguished services to science in both capacities; but there have been

many men who made large contributions to the advancement of science whose work was altogether confined to one of these departments. In a previous article we drew a striking contrast between Copernicus and Tycho Brahe. After the long night of the dark ages the first impulse to modern astronomy was given by the speculations of Copernicus, who could never have accomplished anything as an astronomical observer. But in order that his theories should be confirmed or amended, it was necessary that there should be accurate observations by which to test the theories; these observations were made by Tycho Brahe, whose skill has been the admiration of succeeding astronomers. On Tycho's death, however, the whole result of his life work was a great accumulation of records that bore as much resemblance to a science of astronomy as a heap of bolts, cranks, tubes, and wheels bears to a locomotive. As that heap of parts can become a locomotive only by suitable arrangement by intelligent mechanics, so Tycho's records had to wait until there should arise an interpreter of them before they were really of any scientific value. This interpreter came in the person of John Kepler, who has been well called "the legislator of the stars," as Tycho may very appropriately be called "the shepherd of the stars."

JOHN KEPLER.

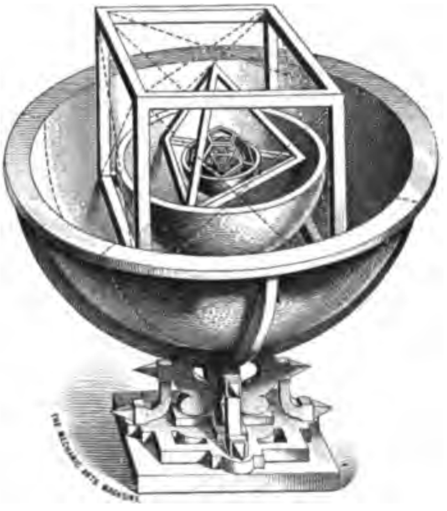
John Kepler was born on December 27, 1571, at Weil, in the duchy of Würtemberg. His father was an idle and shiftless tavern keeper, and our hero was taken from school in his ninth year, to serve as a potboy in the tavern. His childhood was rendered still more miserable by an ignorant and ill-tempered mother. When the lad was four years old he had a severe attack of smallpox, which left him with weak eyes and an impaired constitution. Since he was thus disqualified for the active duties of life, it was thought that he was fit only for the church, which was the only profession that then offered intellectual employment. At the age of seventeen he entered the university of Tübingen, which was then one of the great centers of Protestant theology. In the university the Ptolemaic system of astronomy was still taught in the regular professorial lectures, though the professor of mathematics privately taught Copernican principles. During his residence at the university, Kepler's preferences leaned towards the church, but when the professorship of astronomy at the university of Gratz was offered to him, he accepted it in compliance with the wishes of his friends.

The duties of the chair of astronomy included the prediction of the fates of individuals and nations, as well as the calculation of eclipses and the movements of the heavenly bodies. Kepler, indeed, was an enthusiastic student of astrology, and thought he found in his own life strong confirmation of the doctrine that human affairs are regulated by the aspects of the planets. A large part of his income was derived from the publication of almanacs containing prophecies; some lucky weather predictions in his first almanac gave him a good reputation as a weather prophet. Though he had some faith in astrology, yet it cannot be doubted that he cultivated it chiefly as a means of replenishing his ever-needy exchequer; for he says, "Nature, which has given to every animal some means of supporting life, has designed astrology as the ally and adjunct of the astronomer," and in the preface to the Rudolphine Tables he says: "Astrology, though a fool, is the daughter of a wise mother."

In the beginning of his book, "The Mystery of the Universe," he says: "In the year 1595 I brooded with the whole energy of my mind on the subject of the Copernican system. There were three things in particular of which I sought the causes why they are not other than they are: the number, the size, and the motions of the orbits." The ancients, who held the Ptolemaic system, assigned reasons why there should be seven, and no more than seven, wanderers.

It seemed to the ancients that there ought to be seven wanderers in heaven to correspond to the seven windows in the human head: in the head there are two eyes, two ears, two nostrils, and a mouth; so in heaven there are two favorable stars, two unfavorable stars, two luminaries, and Mercury, which is indifferent. Kepler tried to find some equally convincing reason for the existence of six planets in the Copernican system; he sought for this reason in the occult properties that the ancients believed certain numbers to possess. A number that is equal to the sum of all its factors is called a *perfect* number, and perfect numbers were supposed to have wonderful mystic properties. Now $6 = 1 \times 2 \times 3 = 1 + 2 + 3$, so six is a perfect number, and Kepler fancied that this was the reason for the existence of six planets.

In searching for a geometrical relation among the distances of the planets from the sun, Kepler at first resorted to plane geometry, and endeavored to find the desired geometrical relation by inscribing regular polygons in a circle. After incredible labor in calculation he became convinced that no definite relation among the orbits could be found in this way; but he remembered that, while there is an unlimited number of regular polygons, the Greek geometers had proved that there can be only five regular solids, and he imagined that the five regular solids must correspond to the spaces between the planets. He lays down the law thus: "The orbit of the earth is a great circle of a sphere, which is the norm and measure of all. Round the earth's sphere describe a dodecahedron; the orbit of Mars is a great circle of the circumscribing sphere of this dodecahedron. Round the sphere of Mars describe a tetrahedron, and Jupiter's orbit is a circle of the sphere circumscribing it. Describe a cube about Jupiter's sphere, and a circle of the circumscribing sphere of the cube is Saturn's orbit. An icosahedron inscribed in the earth's orbit gives the orbit of Venus; and an octahedron inscribed in the sphere of Venus gives Mercury's orbit."



KEPLER'S SCHEME REPRESENTING THE PLANETARY SYSTEM.

Kepler proved that the radii of these six spheres are approximately proportional to the distances of the planets from the sun. Bursting into a rhapsody he writes: "The intense pleasure I have received from this discovery can never be told in words. I tired of no labor, I shunned no toil, I spent days and nights in calculation to see if my hypothesis would agree with the orbits of Copernicus." This discovery, though of no value itself, was destined to lead to very important results at a later period, and the immediate effect of its publication was to bring Kepler to the favorable notice of Tycho Brahe and Galileo. Kepler visited Tycho at his observatory and Tycho offered him the post of mathematical assistant; but Kepler declined the offer, saying, "for observations my eye is dull and for mechanical operations my hand is awkward."

At the age of twenty-six Kepler married an heiress of twenty-three, who, though young in years, was old in matrimonial experience, and had been divorced by her former husband. His married life was unhappy; he suffered much from poverty and sickness, and in 1611 his wife died of low fever, brought on by want. His second marriage took place in 1613, and he has left a detailed account of the selection of his bride in a very remarkable letter, in which he discusses the merits and demerits of eleven ladies whom he alleges to have been candidates for the vacant place in his heart and home. His choice fell upon a poor orphan girl, and it is pleasing to read that the marriage proved exceedingly happy. In arranging for a supply of wine for his new household, he had a dispute with the wine merchant, which led to the publication, by Kepler, of a tract upon the gauging of casks with curved sides; in this tract he laid the foundations of what mathematicians call the "Method of Infinitesimals."

(To be Concluded.)

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The White Man's Burden.

Take up the White Man's burden—
  Send forth the best ye breed—
Go, bind your sons to exile
  To serve your captives' need;
To wait, in heavy harness,
  On fluttered folk and wild—
Your new-caught sullen peoples,
  Half devil and half child.

Take up the White Man's burden—
  In patience to abide,
To veil the threat of terror
  And check the show of pride;
By open speech and simple,
  An hundred times made plain,
To seek another's profit
  And work another's gain.

Take up the White Man's burden—
  The savage wars of peace—
Fill full the mouth of Famine,
  And bid the sickness cease;
And when your goal is nearest
  (The end for others sought)
Watch sloth and heathen folly
  Bring all your hope to nought.

Take up the White Man's burden—
  No iron rule of kings,
But toil of serf and sweeper—
  The tale of common things.
The ports ye shall not enter,
  The roads ye shall not tread,
Go, make them with your living
  And mark them with your dead.

Take up the White Man's burden,
  And reap his old reward—
The blame of those ye better,
  The hate of those ye guard—
The cry of hosts ye humour
  (Ah, slowly!) toward the light:—
"Why brought ye us from bondage,
  Our loved Egyptian night?"

Take up the White Man's burden—
  Ye dare not stoop to less—
Nor call too loud on Freedom
  To cloke your weariness.
By all ye will or whisper,
  By all ye leave or do,
The silent sullen peoples
  Shall weigh your God and you.

Take up the White Man's burden!
  Have done with childish days—
The lightly-proffered laurel,
  The easy ungrudged praise:
Comes now, to search your manhood
  Through all the thankless years,
Cold, edged with dear-bought wisdom,
  The judgment of your peers.

(*By Rudyard Kipling; by permission of McClure's Magazine.*)

This poem, "The White Man's Burden," saw the light in February of the current year. When it was written, the treaty of peace between the United States and Spain was before the senate for discussion, and the question of the ownership of the Philippine Islands was still undecided. Powerful arguments had been made for and against their acquisition by the United States. The "ayes" dwelt on the naval and commercial value of the archipelago, and on the prestige which the country would gain by such an enlargement of her domain; the "nays" pointed to the Constitution of the United States, and urged the nation to consider the expense attending the occupation of such distant territory, the cost of the necessary fleet and garrison for its defense, and the uncertainty of pecuniary profit. Rudyard Kipling's strong and forcible verses were pitched in a higher key; he ignored all questions of national gain or loss, but brought home to many a waverer the conviction that there lay before this country a duty—an opportunity; should she take it or leave it? It might or might not bring tangible recompense, but was that to be the first consideration? Duty is its own reward. "Am I my brother's keeper?" is a question as old as the story of the human race; and Rudyard Kipling answered it with an emphatic "Yes!" when he wrote "The White Man's Burden." He has written better verse, but nothing that appeals more strongly to the instincts of manliness, courage, and self-sacrifice.

"The White Man's Burden!" The phrase caught the people's ear, and touched the people's heart. In these few words Rudyard Kipling has created for himself a monument which may endure when all else that he has written is forgotten. He sums up in them the history of centuries that are past, and prophecies of centuries to come. He speaks as a prophet speaks, warning and exhorting; he stands at the parting of the ways, and

points a kindred nation to a toilsome road, leading to a very distant goal, to be attained not by the workers of today, but by future generations, who will call their forefathers to account if the work of today is ill done.

America has unexpectedly become responsible for the government of the Philippine Islands; the obligation has been forced upon her by a combination of circumstances which could hardly have been foreseen. In contemplating the task which lies before her, if the White Man's burden is to be borne bravely and patiently, it is natural to institute a comparison with the countries in which her Anglo-Saxon kindred have done and are doing similar work. Great Britain rules "dark peoples" on two continents; but Kipling had in mind India, in which much of his life has been spent, rather than Africa, when he wrote the verses which are so pregnant with meaning for Americans at this juncture; and as India and the Philippines are tolerably near neighbors, the experiences of the White Man in the two countries may correspond in some points, notwithstanding the difference in their circumstances.

America comes into possession of the Philippines as a whole; Great Britain acquired her Indian empire very gradually. Close commercial relations had been established for many years before there was any thought of conquest. Just 300 years ago the East India Company began to trade at Indian ports. As years went on the company came into collision with the trading interests of other European nations; the battles of Europe were fought on Indian soil, with the help of native troops on both sides. One after another great tracts of country came under British control. The control was that of a private company, acting under the authority of charters granted by parliament; but forty years ago the company ceased to exist, and its powers and rights were transferred to the British government.

The responsibility of America for the Philippines falls to her in different fashion. Her commercial relations with the islands were quite insignificant. She seems to seize them by force, yet it may more truly be said that they are thrust on her by the inexorable logic of circumstances. White men and white men's methods are not strangers there. The Filipinos have had glimpses of modern civilization, and parts of the islands have had experience of a government which uses its dependents for its own purposes. What manner of men is America going to send there to regulate the civil affairs of the country when the work of the soldier has been done? No one who goes in hope of a life of ease, or to seek a "fat place," can ever make his mark, or raise the islanders' standard of life, and thus really bear his share of the White Man's burden. Such work is done by self-sacrifice, unconscious it may be, but always real.

Kipling's suggestive phrase puts the work of the conquering White Man in the East in a very different light from that in which it is usually shown. What is this burden which is to be borne by him? He who is a civilized, self-restrained, self-governing human being, the product of a favorable environment for many generations, is called on to use the powers with which he is endowed for the benefit of the millions of the East whose racial development seems to have been arrested. He is placed on a higher level than the greedy fortune hunter who passes his life among strange scenes, in the midst of a subject people, only for the sake of what he can gain from them; he goes primarily to make a living and a place for himself in the world, it is true; but he earns that living and that place by honest hard work for the people among whom his lot is cast, with small thought of self and with resolute courage. He has to teach them to rule and govern themselves; he must bear with the weakness and vices of the "new-caught, sullen peoples, half devil and half child," the product of generations of oppression, wrong, and cruelty. He must teach them that a White Man, worthy of the name, never "says the thing which is not"; that his eyes and ears are always open; that he puts his own hand to work for the people whom he rules; that he will protect the weak and aid the suffering; that law will be fairly and justly administered; that crime will be punished, by whomsoever committed; that taxation shall not be extortionate; that customs, persons, and property shall be respected; and that, according to the old Saxon phrase, every man shall be "law-worthy." Exactly in so far as he conforms to such an ideal will he bear his share of the White Man's burden. The "silent, sullen peoples" will learn such lessons only from those who live among them and become their friends. The lessons are costly to the teacher; every such pioneer goes with his life in his hand; and if the story of India is to be repeated on a small scale in the Philippines many will pay the price by disease or by violence before their work has produced visible results.

The material works which await the White Man's hand in the old countries where the applications of modern science are unknown hardly need enumeration; they suggest themselves to every mind. But how will they be received? The harbors, the roads, the railways, the bridges, the telegraphs, promoting easy communication, and the canals for irrigation, or the works which shall protect lowlands from floods, will be recognized as of value; they will be tolerated, and in time will be welcomed by the people. They will see also that it is for their good that robber bands are swept away, and that the wild beasts which terrorized their villages are gradually exterminated. But when there is interference with their established customs, the killing of the aged or of infants, or the burning of their widows, they murmur and rebel. Or when the White Man tries to "fill full the mouth of famine, and bid the sickness cease," he will find his earnest endeavors checked by the dark peoples' customs and beliefs; the food which he provides will be unacceptable, the methods employed by modern sanitary science will be accounted sacrilegious; and the would-be benefactors must begin at the beginning again, and invent new methods which, next time (for there is always a *next time* to famine and pestilence in the East), may accomplish the work without outraging the feelings of the sufferers.

And meanwhile, the neighbor nations will stand by, observing and publishing all the failures and mistakes, giving little credit to the hard-won partial successes of those who are doing the work. Yet however thankless the task, the voice of one who knows reiterates the call:

Take up the White Man's burden,
  And reap his old reward—
The blame of those ye better,
  The hate of those ye guard.

* * * * *

By all ye will or whisper,
  By all ye leave or do,
The silent, sullen peoples
  Shall weigh your God and you.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR 1897.

THIS interesting and instructive volume, which is issued by the Government Printing Office, Washington, D. C., consists of two parts. The first part is the report proper, and deals with the work of the Institution, expenditures, appropriations, buildings, funds, administration, and other matters of little interest to the general reader. We must mention, however, the account given in the report of the publications of the Institution, which, for the year in question, aggregated nearly 10,000 pages, "covering to a greater or less degree nearly all branches of human knowledge." A very important contribution of the Institution to scientific literature was a "Catalogue of Scientific and Technical Periodicals," containing the titles of more than 8,500 technical and scientific periodicals in all languages.

Worthy of notice is, also, the ethnological work of the Institution, which has for some years past been recognized as the most reliable source of information, with respect to the customs, religion, languages, traditions, and actual conditions of the American Indians. The Institution devotes a large sum to this kind of research, and has in its service some of the most distinguished specialists in the country.

By far the most interesting part of the Report is the "General Appendix," which consists of several essays written by the foremost scientists of the time, on almost all subjects that are of either importance or interest to the student of natural science. This part comprises about 600 pages. The essays, which deal with astronomy, chemistry, physics, physiology, mechanics, geology, meteorology, biology, botany, etc., are written in untechnical language, by men that are masters of the subjects they treat; the result being a collection of valuable information, from the reading of which much pleasure and instruction may be derived. Space does not allow us to make even a brief review of these essays; but we shall call attention to a few points that may be of interest to our readers.

Mr. G. H. Darwin gives a very clear explanation of the action of the moon in producing the tides, and the effect of the latter in retarding the rotation of the earth, and shows us that in the distant future there may come a time when the day and the

month will be of the same duration; that is, when the earth will revolve on its axis in the same time occupied by the moon in revolving about the earth. This day and month will contain 55 of our present days.

Mr. Elihu Thomson writes on "Electrical Advance in the Past Ten Years." Referring to the many things accomplished by electricity, he says: "That paragon of nature, the diamond, can now be fashioned in an electric crucible from plain black soot." Mr. W. Crookes will soon explain to us how this is done. It is surprising to see how new almost all electrical inventions are, how fast they have developed, and how perfect they have become. The telephone dates from 1876. As for electric locomotion, Mr. Thomson says that "at a convention of street-railway men, held so recently as 1887, a discussion of electric traction as applied to horse railways was vigorously criticised as a waste of time which might have been better applied to practical subjects, instead of to such a fanciful or theoretical one. In fact, the contention was that the care and feeding of horses should take precedence of so unimportant a subject as electricity."

There is a most interesting article and several brief notes on the X-rays, written by Dr. W. C. Roentgen, the discoverer of this wonderful manifestion of electrical energy.

Mr. S. P. Langley, the great expert on "Mechanical Flight," writes on this ever-fascinating subject. Especially worthy of notice is the historical sketch he gives of his experiments and inventions, of his unsuccessful trials and his failures, which, bringing to disappointment what he had thought well-founded expectations and hopes, often discouraged him and almost deterred him from continuing work so unpromising. But his patience and perseverance—great and rare qualities, without which no inventor can hope to succeed—overcame all obstacles, and his last inventions, which he calls *aerodromes*, and describes in this article, have done much towards the solution of the vexed problem, "How can we fly?" Intimately connected with this problem is that of the flight of birds, which is very ably discussed in an article "On Soaring Flight," by Mr. E. C. Huffaker. The facts and experiments he describes are most interesting—some of them most curious.

Among other things relating to "Diamonds," Mr. William Crookes gives a good description of the laboratory production of the precious stone. The principle is comparatively simple. Pure iron is placed in a crucible with fine charcoal, and heated by an electric arc to about 4,000° C. The iron, of course, melts, and the carbon of the charcoal is dissolved in the molten metal, just as sugar in water. The whole mass is now plunged into cold water, which almost instantly solidifies the outside of the molten mass, thus forming a thick and rigid crust, preventing the remaining portion from expanding. Now, as this portion solidifies, it tends to increase in volume, and as this is prevented by the solid crust, an enormously high pressure results, under which the dissolved carbon separates in the form of brilliant crystalline fragments — perfect diamonds. Such diamonds, however, are exceedingly small (the largest one ever made being less than .04 inch in diameter), and the process of manufacture exceedingly expensive.

To those who take special pride in calling themselves "practical men," and who, "exercising the prerogative of ignorance," speak with contempt of the "theoretical man," we recommend Mr. J. J. Stevenson's admirable article on "The Debt of the World to Pure Science," where they will learn that, while the theoretical man does not concern himself much with dollars and cents, bread and butter, he has invariably furnished the material out of which wealth, civilization, and prosperity, as understood by the "practical man," have grown; and that the said "practical man," in his disparagements of pure science, shows at once his ignorance and his ingratitude.

There is an essay by Lord Kelvin (formerly Sir William Thomson) on "The Age of the Earth as an Abode Fitted for Life." His object is to refute the assumptions of some geologists who hold that the earth has been the abode of living beings during hundreds and perhaps thousands of millions of years past. From physical considerations, he concludes that the age of the earth, in its present form, cannot be much, if at all, above 24,000,000 years. The reader, however, must not take such figures and computations as relate to these romote periods very seriously. They are all founded on more or less plausible, more or less objectionable hypotheses; and, what is worse, they are usually the results of investigations undertaken with the object, explicit or tacit, of either substantiating or discrediting the biblical accounts of creation (for, notwithstanding our boasted scientific spirit and impartiality, we have not yet become sufficiently hardened or unfeeling to exclude venerable theology from our investigations).

ROASTING AND BAKING AS A FINE ART.

W. M. Brown.

A Novel Way of Roasting or Baking Meats: Seasoning From the Inside Outwards. How to Obtain Boneless Shad.

TO THE truly scientific mind there is nothing too insignificant for the most careful examination and painstaking experiment. Among the many things that Count Rumford made subjects of research there will be found almost all that pertains to the kitchen; the making, the maintaining, and the using of culinary fires, stoves, and chimneys, the art of cooking, and almost everything connected therewith. And this scientist not only investigated these

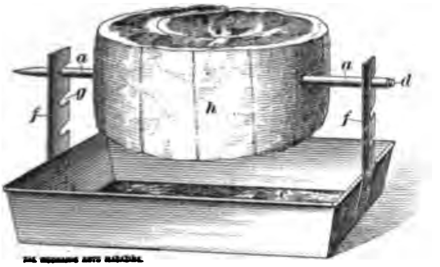


Fig. 1.

things theoretically, but, at great expense and labor, experimented with them practically, and, what is better still, wrote copiously on them, as he did on everything else he investigated, leaving a store of useful knowledge from which posterity may draw for all time. There is no cook or chef of today who may not with great profit read his works.

Happily it is now the fashion for many of our popular periodicals to devote more or less space to these very subjects; indeed, no publication that hopes to win and maintain a place in the household can afford to entirely neglect them. In the March number of this magazine there appeared an article by Mrs. Henry Esmond on roasting, broiling, and baking, which was both instructive and entertaining.

While not professing to be a chef, nor to being possessed of any wonderful amount of knowledge on the subject of cooking in general, the writer desires to present what he believes will prove to most of the readers a new method of roasting or baking meats.

Having a properly heated oven and a baking piece to prepare, we next need a properly arranged dripping pan. Fig. 1 shows one, in which *a* is a steel spit, or rod, resting in upright sheet-iron brackets *f* riveted to the ends of the pan, and having notches *g* in which the spit may rest or turn; *h* is the meat resting over the pan *e*, with the spit thrust through it. When so arranged, the meat may be turned with ease whenever desired.

Now, the spit *a* is more than a simple rod, as shown in Fig. 2; it is hollow—a tube, in fact—with holes at about the middle of its length that run crosswise of the spit and communicate with the central bore *c*; one end is drawn down to a sharp point, and the other end is stoppered by a plug *d*. This spit should be about $\frac{1}{2}$ inch outside diameter, and made by drilling a $\frac{5}{16}$-inch hole into the rod for about half its length, and the holes *b* should be about $\frac{1}{4}$ inch diameter.

The meat should be so spitted that the openings *b* are as nearly in the center of the meat as possible; and the notches in the side brackets should be a trifle higher on one side than the other, so that the spit can be placed in a sloping position with the plugged end a little higher than the pointed end. This insures the seasoning getting into the meat. A dripping pan so prepared, and the spit so arranged, costs but a trifle. Prepare the meat for baking, but do not use any salt or other seasoning

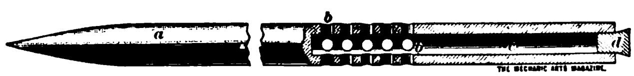


Fig. 2.

on the outside of the meat. When the spit has been thrust through the meat, practically as shown in Fig. 1, draw the plug *d*, which may be of wood, and place in the bore as much salt, pepper, or other seasoning as is deemed necessary to season the meat, and ram it well to the bottom of the hole and replace the plug tightly. Place the pan and contents in the oven. The result will be that the heat of the oven will sear over the outside of the meat, closing the pores and thus preventing the escape of

the juices, and the spit, becoming hot, will sear the meat where the spit enters it, and thus but very little juice will escape around the spit.

As the heat strikes inwards the juices will enter the holes *b* in the spit and will mix with the salt and other seasoning, and the liquid thus formed will permeate the entire body of the meat, acting and striking out from the center, thus seasoning it from the center outwards, instead of from the surface inwards, as is the case when the seasoning is applied to the surface. It will be evident that the seasoning, being in the center of the meat, cannot be dried into a crust and caused to but partly perform its work, as is always the case when it is applied to the outside of the meat. Being thus free to disseminate itself in every direction, without becoming dried or crusted, and having no hard outer crust to penetrate, the meat will be seasoned with absolute uniformity throughout, and will have a flavor impossible to obtain by the usual manner of seasoning.

After the meat has become seared over, place in the dripping pan such fats, as suet, butter, or dripping, as may be desired, and baste the meat occasionally to prevent the outer surface from becoming dry and hard. If a true roast is desired and the fire is properly arranged for it, the dripping pan may be set before the fire and the meat turned as is ordinarily done in the process of roasting.

The spit is easily kept clean inside by the use of a wire with a swab at one end, and if laid away in a dry place will not rust. Be sure to keep the holes *b* open, as they will tend to become choked.

It is believed this method of roasting or baking meats will be new to most readers, and it is too much to hope that it will become generally adopted. The difficulty will be that it is something new and requires preparation, and, at first, some little attention to detail. These are the stumbling blocks in the way of the great majority of female cooks, not with the professional ones so much as with "milady" who attends to her own culinary affairs. The ordinary time-serving servant, will never mend her ways unless the mistress forces matters, and this she is loath to do. The only reason why male cooks take precedence in cookery is due to the abnormal conservatism existing among women. To think for themselves and branch out into untried fields seems to have unnecessary terrors for them.

Once a certain manner of doing a thing is acquired, any suggested change is unheeded. It is sometimes lamented that young ladies do not learn cooking at home from mother, and that they prefer to play the piano or amuse themselves in any manner that comes to hand. The fact is, it is oftener a blessing in disguise, for once a particular style of cooking is acquired nothing can change it, especially if acquired when quite young, and mother's unscientific and faulty methods are perpetuated for years, to the discomfort of all who depend upon the daughter for the pleasures of the table. It is far better that correct knowledge be attained after the young woman has arrived at maturer years, than that wrong notions be inculcated in early youth, from which her natural conservatism will prevent her from departing.

The writer once induced a lady to prepare and cook a shad in the following manner: Clean the fish; lay it upon its back, and with a sharp knife cut on each side of the backbone down the whole length of the fish, deep enough to sever the ribs from the backbone. Place the fish on its back in an earthenware dish large enough to allow of its lying at full length, thus exposing the two incisions. Pour over the fish sufficient strong cider vinegar to cover it and let it remain for from two to four hours. Broil or fry in the usual manner.

The first objection raised was that the result would be a pickled fish for dinner, but when assured she would have nothing of the kind, she tried the experiment. To her utter surprise, when the fish was eaten, she had a boneless shad, the flavor not being in the least disturbed by the pickling process. The acid in the vinegar had simply turned the troublesome bones to a chalky consistency and they could not be detected when eaten. Although the experiment was an absolute success, she has never repeated it. Why? Oh, she didn't like to be trying new things, the old way was good enough, and bone mining has gone on ever since when she has had shad for dinner. This is the delirium tremens of conservatism.

The culinary art, like any other, would become interesting, and cease to be the drudgery it is, if cooks would study and think, instead of following obsolete ways, simply because they were the ways learned in early youth. Considering the importance of the subject, it is surprising how little is known by the general public about cooking. There are plenty of faultfinders if a meal is not just what it should be, but comparatively few who know anything about cooking.

GOOD SCHEMES

LAYING OUT GEAR-TEETH.

W. H. Booth, London, England.

Mr. Harland Tuttle's method of laying out gear-teeth, as described by him in the Good Schemes of your April number, is particularly interesting to me because it is almost identical with one that I learned and practiced in my apprentice days. At the same time it is far from common to find patternmakers using this absolutely correct system. In place of sheet zinc, we were accustomed to use a piece of tinned plate, which we brought to a dull dead surface by rubbing with fine sandpaper. Having described the various curves, we employed them as grinding templets, to which we fitted the cutters. The cutters were then fixed in the revolving spindle of the dividing engine. Our dividing engine was a large machine on which we turned up the blank patterns and got all ready for dividing. On the spindle that carried the pattern to be cut, there was a wheel of 360 carefully cut teeth, and it was arranged with a number of change gears so that we could cut wheels of any number of teeth. Our wheel patterns were thus very accurate, and truly pitched. The revolving cutters finished the teeth, except for a final sandpapering. Mr. Tuttle, in his article, omits one little detail that we practiced, namely, the putting in of fillets at the junction of the teeth with the rim. It is common to see these left sharp, not filleted at all, as shown in Fig. 5; again, others put

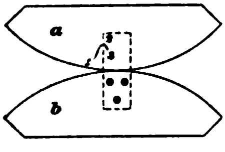


Fig. 1.

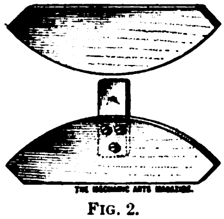


Fig. 2.

in circular fillets. The latter neither looks well nor is it correct. I have seen such circular fillets put in so much too full that the points of the teeth of each wheel touched on the fillet and had to be filed off. The fillets ought to be just as correctly shaped as the rest of the tooth curve, and this can best be done in the following manner: In Fig. 1, *a* and *b* are two rolling circles of the pitch diameters of the respective wheels. To one of these, *b*, a projecting piece is attached, as shown in Fig. 2, and this is furnished with a point, at a distance from the curve equal to the distance that the tooth projects beyond the pitch line. If *a* and *b* are now rolled together in firm contact, the scribing point draws a curve *1 2 3*, as shown. The part of

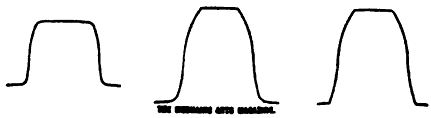


Fig. 3. Fig. 4. Fig. 5.

this curve between *1* and *2*—from *1* to its lowest point—is then an appropriate form of fillet for joining the curve of the flank of the tooth to the rim of the wheel, as in Fig. 4. In a set of wheels, of course, exact opposites cannot be employed for this purpose, but that curve must be selected which will give the strongest tooth without contact at any point being possible. If the largest wheel and the smallest of a set clear each other, all the others of the set will do so. Not only should there be a properly formed fillet at the base of the tooth, but it would be good practice to take off the very sharp edges at the point of the tooth, as shown in Fig. 3; in England, this is done now on large wheels by all the best makers. Fig. 3 also shows the new form of tooth (as regards *length*) now recommended in place of the old form of Figs. 4 and 5. This shortening of the tooth adds much to its strength, and the wheels run every bit as smooth; it has been adopted by some of the best concerns in England and America, and should be strongly advocated by those interested in gearing.

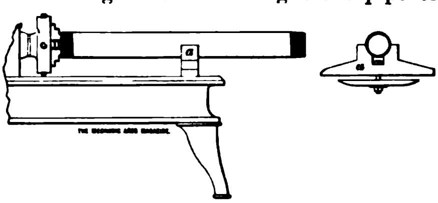
Here I would like to say something about the keying on of gear-wheels and wheels in general. For years I have followed the system that was first adopted, I believe, on the Porter-Allen engine, and I have never known it to fail, though I have had endless trouble convincing some men of its merits. As is perhaps known, the method consists in boring the wheel to the same diameter as the shaft, and then shifting the wheel about $\frac{1}{32}$ inch out of center and reboring to the same diameter, thus cutting a thin crescent out of one-half of the hole, and then putting the key in at this side, thus drawing the

opposite side of the hole hard against the shaft, thereby fixing the wheel absolutely and truly central. Because the wheel (before keying) is loose on the shaft, the non-informed man declares it is impossible to fix it with a key so as to run true. He thinks he knows it all, but the fact is he does not see that, while with the old system the wheel and shaft are in hard contact along two lines only (namely, at the key and diametrically opposite), with the new system the wheel and shaft are in hard contact at the key and *half way around the circle on the opposite side.* Of course, where a wheel is bored small and then pressed on, there is contact all around the bore, and this is the best job; but then, such a fit is not practicable in ordinary work, where the wheel may require removal away from shop facilities, and then the method described should be used.

TO THREAD A LONG PIPE IN A SHORT LATHE

R. H. Hampson, Armiston, Ala.

THE SCHEME described here will, I think, be of interest to some of the readers of THE MECHANIC ARTS MAGAZINE. A 6-inch pipe on the boilers at our works was leaking; the engineer and the foreman of the machine shop decided that, if two new threads were cut farther back on the pipe, the leak would be stopped. The foreman said that unfortunately the new thread could not be cut in our shop, as the pipe was 9 feet long and our lathe was only 5 feet between centers; and we had no pipe dies. I told the foreman that, lathe or no lathe, I could cut it, and he told me to go ahead. I caught the pipe on

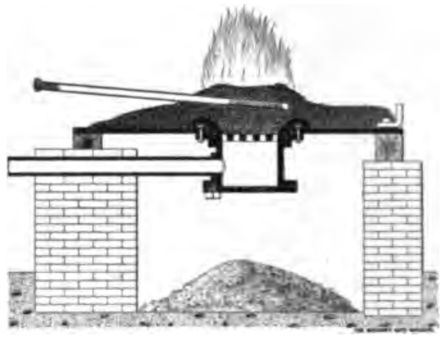


the inside by the chuck jaws, as shown in the enclosed sketch, letting the pipe stand away from the chuck so as to give clearance for the tool; I made a wooden steady rest, as shown at *a*, the one belonging to the lathe being too small, and bolted it to the bed with the anchor plate belonging to the lathe rest. I trued up the pipe and chased the threads up against the chuck, and made a good job of it too. Since then I have chased a good many different sizes and lengths of pipe in the same way.

FOR BLACKSMITHS.

E. O. Hurts, Schenectady, N. Y.

I RAN ACROSS the following good scheme in a blacksmith's shop some time ago, and it may help out some who have to temper reamers, bits, close-coil springs, and the like: Take a piece of pipe of suitable diameter



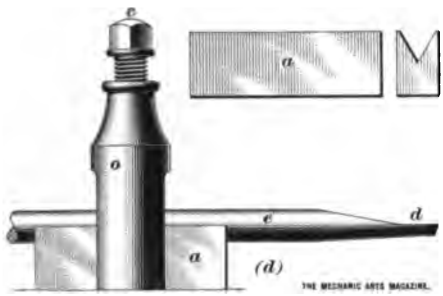
and convenient length, and place inside it the tool to be tempered; now plug up the farther end with waste, to prevent the hot gases from the fire from passing up and through the tube; all somewhat as shown in the accompanying sketch. By this simple means, the pipe is kept cool as long as one cares to use it.

A USEFUL BORING TOOL.

J. Breslove, Toronto, Ont.

THE GREATEST drawback of the old-time boring tool is the tremendous amount of forging required, and the necessity of having various lengths to correspond with different sizes and lengths of holes. I here give description of a lathe boring tool that does not require one-tenth the forging of the ordinary tool, and the same tool may be used for any length of hole, as the tool may be so shifted that there is no necessity for any undue spring. The dimensions given are for a tool to be used on a 16-inch lathe; for other lathes, make in proportion. Take a piece of ordinary machinery steel, about 3 in. × 1 in. × ⅝ in., see *a* in the figure, and. on the ⅝-inch face, cut in it as shown a 60° V way; this block *a* is then the holder for the tools, and may be used for any size from ⅛ to ¾ inch. Now take a piece of ½-inch round tool steel any desired length and forge the end in the ordinary way for a boring tool, as at *d*. If the hole to be bored is smaller than ½ inch, use smaller size of steel to suit. This is all the making that is

required in this tool. To use: put the block *a* in the tool post holder *o*, as shown at (*d*), lay tool in the **V** groove, and tighten set-screw *c* on to it. Let the tool project beyond



the block *a* only a trifle more than the depth of the hole to be bored; thus all unnecessary spring is avoided. Threading and other tools can be held in the same block.

FOR DRAFTSMEN.

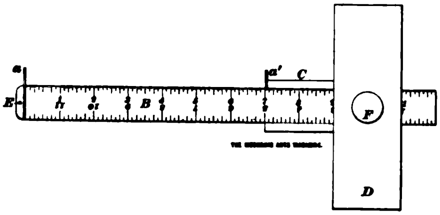
D. C. Walter, Toledo, Ohio.

THE FOLLOWING will be found a very convenient way of putting down and stretching paper for large drawings: After moistening the paper on the back in the usual manner, instead of turning up a half inch all around, tear some long strips of tracing cloth about 1 inch wide and coat one side of them with good heavy mucilage. Place the moistened paper in position on the board, and lay the strips of cloth around the edge, with one half over the paper and the other half on the drawing board; do this all round the edge of the paper. When dry it will be found that the paper is perfectly stretched, and the actual work of mounting is done in one-fourth the time required by the old way. The strips can be removed by simply pulling off, and can be used again.

A HAPPY COMBINATION.

Linwood C. Plummer, Fort Fairfield, Maine.

THE ACCOMPANYING sketch represents a home-made device, of my own construction, that I find useful in a variety of ways. Referring to the sketch, *B* is a graduated steel scale; *D* is a hardwood head, in which, and also in the sleeve *C*, the rule slides; *F* is a knurled-headed setscrew to hold the rule at any desired position. At *a*, brazed to the rule, is a strip of metal; at *a′* secured to *C*, is a similar strip; together these become (1) a *caliper*. With the rule extended to the right through head *D* the device becomes (2) a *try square*, and (3) a **T** *square;* while on the same side of the head, the device is also



(4) a *depth gauge*, for mortises and box work not exceeding 8 inches in depth. At *E* I fixed a hardened-steel point, and this converts the device into (5) a *marking gauge*. The tool has thus five distinct uses.

TESTING HELICAL SPRINGS.

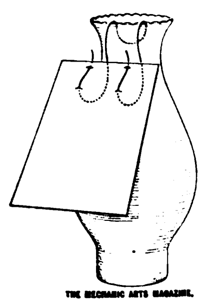
Newark.

A FEW DAYS ago I was testing some large springs by closing them, coil to coil, in my bench vise. The third one broke and flew to pieces, one of the fragments passing dangerously near my head. I was in no hurry to test any more of them, until it occurred to me that, if I enclosed each spring in a piece of pipe a trifle shorter than the closed spring, I would be perfectly safe in any event. I did so, and though several of the springs broke, I was in no danger whatever, the pieces staying harmlessly in the pipe.

A LAMP SHADE.

Student.

A CONVENIENT lamp shade for any one engaged in reading or other close work at night can be quickly made, and at practically no expense, out of a square piece of paper or thin pasteboard — preferably of a dark-green color—fixed to the lamp by means of a piece of wire bent to the shape shown in the figure. That part of the wire passing through the paper can be bent so as to vary the angle of the shade and thus increase or decrease the amount of light thrown around.



By passing the wire through the paper in the manner indicated, the paper is prevented from coming in contact with the chimney.

TRADE NOTES

A UNIVERSAL BEVEL PROTRACTOR.

THE ILLUSTRATION on this page represents the newly improved universal bevel protractor made by Brown & Sharpe Mfg. Co., Providence, R. I. This will be found a very convenient tool for use in any machine shop or manufactory; its uses as a protractor are practically unlimited, as the cuts on the opposite page go to show, these being but a few of its many applications. It is well adapted for all classes of work where angles are to be laid out or established, and, as the graduations on the dial are *accurate*, and all the alinements correct, *absolutely precise* measurements can be obtained. The workmanship, like that upon all tools turned out by the Brown & Sharpe Mfg. Co., is the very best of its class.

The dial is graduated in degrees entirely around the circle, and one-half and one-

quarter degrees can easily be estimated; it turns on a large central stud, hardened and ground, and when set can be rigidly clamped by the thumb-nut shown in the cut. The blades, which are about $\frac{1}{8}$ inch thick, can be drawn out to their full length and clamped independently of the dial. The graduation lines are below the surface, and are thus protected from wear. A feature that is of particular interest, and one that will be appreciated by draftsmen and toolmakers, is that one side of the stock is *flat*, thus permitting the instrument to be laid upon the paper or work. The blade usually supplied is 6 inches long, but a 12-inch blade can be furnished if desired. The price with 6-inch blade is $8.00; this in morocco case is $9.00. With 12-inch blade, the price is $9.00; in morocco case, $10.50.

BOOKS AND CATALOGUES.

THE STEAM ENGINE INDICATOR. Directions for the selection, care, and use of the instrument and the analysis and computation of the diagram. Compiled from the regular issues of "Power." With revisions and extensions comprising numerous tables. The Power Publishing Co., New York. Price, $1.50.

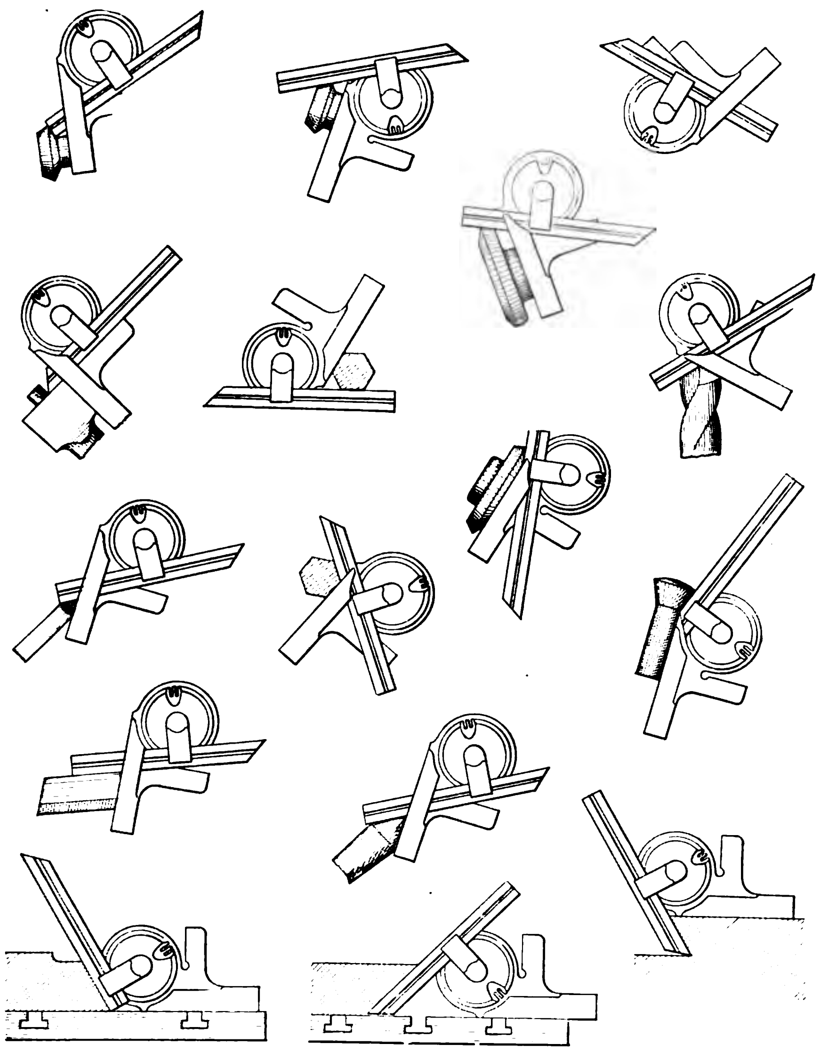
Of the many books that have been written on the steam-engine indicator the present one is probably best calculated to fill the wants of the practical engineer. It treats the subject in a thorough manner without being long-winded. It presupposes a certain familiarity with the indicator and its uses, therefore is not overloaded with a chapter describing the various makes, but starts off with an enumeration of the requirements of a perfect instrument, giving the reader advice to guide him in the purchase of an indicator suitable for his wants. The discussion of the diagram, its various parts, and the causes of their deviations from the ideal lines, is excellent. The planimeter comes in for its share in Chapter XII. Here, too, more importance is placed on the practical use of the instrument than on its theory or on the description of its various forms. A number of tables facilitating the work of computation, some of which we believe are original with the author, are given. Two chapters are dedicated to diagrams of compound engines, a subject not often found so well treated in books on the indicator.

We take pleasure in strongly recommending the book to students and engineers alike. Having given the author his dues, we cannot refrain from mentioning that the typographical execution of the work is not of the same standard, a fact that is regrettable, inasmuch as the figures of the tables are in many instances indistinct and in some places entirely obliterated.

BROWN'S MANUAL OF ASSAYING, eighth edition. Published by E. H. Sargent & Co., Chicago. 550 pages, 134 illustrations, with one colored scorifier plate. Price, bound in cloth, $2.50; in leather, $3.00.

Brown's Manual has gone through too many editions to need special introduction

to assayers or those interested in similar work. It has always been one of the best manuals on the subject for any person not wishing to go into the heart of the subject, as the manual does not introduce chemical equations or difficult mathematics, but has always been a plain, common-sense manual. mathematical and typographical errors that had been discovered in the previous editions, so that at present the book stands as a thoroughly tested and reliable manual on the subject it is intended to treat on. In the note upon this edition, the author, Mr. Walter Lee Brown, takes occasion to call



In glancing over the present edition it will be noticed that the general appearance and typographical work in the book is of a higher standard than most similar publications. The list of useful books more or less connected with assaying has been revised and brought up to date, and a careful investigation has been made to correct all of the attention to the fact that Mr. Charles F. Chandler, of the School of Mines of Columbia University, New York City, deserves the credit for having devised and put into use the "Assay-Ton" system of weights, a system that has proved of such great use to all assayers, and which has always been described in Brown's Manual.

MECHANICAL MOVEMENTS, POWERS, DEVICES, AND APPLIANCES. Used in constructive and operative machinery and the mechanical arts. For the use of inventors, mechanics, engineers, draftsmen, and all others interested in any way in mechanics. By Gardner D. Hiscox, M. E. Norman W. Henley and Co., New York, publishers. Price $3.00.

This book contains a classified collection of all sorts of mechanical movements and combinations, good, bad, and indifferent. Its preparation must have been no small task, considering that it contains over sixteen hundred illustrations, each accompanied by a short description. There are 400 pages of it. There can be no doubt as to the utility of such a collection. It is to serve mostly, we take it, to give welcome suggestions for the solution of mechanical problems, to aid and stimulate, as it were, the inventive faculty. Taking the intention of the compiler to have been such, from his recommendation of the book to inventors, mechanics, etc., we cannot but feel that he has overshot the mark in some cases. Thus, we do not see the utility of a picture of a typewriter, or a bassoon, or any complete instrument, appliance, or machine. If, on the other hand, the book were intended to be a mechanical dictionary, it would be woefully lacking, as it then should contain ten times as much. But this is evidently not the author's aim. The book is certainly worth every penny of its price, and more, to whoever can make use of it.

NOTES ON DESCRIPTIVE GEOMETRY, WITH EXERCISES. By Prof. W. L. Aines, Worcester Polytechnic Institute. Third edition, 89 pages. Published by Moore & Langen Printing Co., Terre Haute, Ind. Price 50 cents.

The distinguishing feature of this little book is the large quantity of matter crowded into a small space. All the usual problems on points, lines, and planes, are given in the first sixty pages; the remaining thirty pages are devoted to the following subjects: tangent planes, sections, intersections of surfaces, development of surfaces, helicoidal surfaces, and the hyperboloid of revolution. The extreme brevity is largely due to the concise notation adopted. We quote one problem to show the style of presentation:

"PROBLEM 22.—*Given one projection of a line contained in a plane, to find the other projection.* Given the planes *1* and A^h, Fig. 50. This determines the H trace and H projection of the V trace of A. Since the V projection of the H trace lies in X, and the V trace lies in 1^v, A^v which contains these points is readily determined."

When one has mastered the notation employed—and this is an easy matter—these few words, in connection with the figure, give a clearer conception of the problem than the usual description of four times the length. Recognizing the fact that the third-angle method of projection is destined to universal use, the author has employed the third angle almost exclusively in problems and exercises. This feature will make the book peculiarly acceptable to draftsmen. A valuable feature of the book is the large number of exercises—206 in all; many of these are practical in their nature. As the name indicates, the book consists of notes originally prepared for students' use in the classroom. There can be no question that the book is well suited to classroom instruction; and while its conciseness may prove an objection to its use outside of the classroom, we believe that any one desiring to study the principles of descriptive geometry will do well to add the book to his library.

Copies may be obtained of Mrs. S. P. Burton, Rose Polytechnic Institute, Terre Haute, Ind.

NEW BOOKS OF INTEREST.

Any of which can be obtained from The Technical Supply Co., Scranton, Pa.

"Haswell's Mechanics' and Engineers' Pocketbook." Sixty-fourth edition. Chas. H. Haswell. $4.00.

"Machine Design." Part II. Forrest Jones. $3.00.

"Elementary Physics and Chemistry." R. A. Gregory and A. T. Simmons. 50 cents.

"Blackboard Drawing." Hints on sketching natural forms. W. E. Sparkes. $2.00.

"Practical Notes on Hydraulic Mining." Second edition. G. H. Evans. $1.00.

"Internal Wiring of Buildings." H. M. Leaf. $1.40.

"Sewer Design." H. N. Ogden. $2.00.

"Locomotive Engine Running and Management." Twenty-first edition; rewritten. Angus Sinclair. $2.00.

"Chemical and Metallurgist Handbook for the Use of Chemists." Pocketbook. J. H. Cremer and G. A. Bicknell. $3.00.

"Characters of Crystals." Alfred J. Moses. $2.00.

"Stars and Telescopes." Popular astronomy. D. P. Todd. $2.00.

"Massage and the Original Swedish Movements." Fourth edition; revised and enlarged. Kurre W. Ostrom. $1.00.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(137) In HOME STUDY MAGAZINE, January, 1899, Answers to Inquiries, No. 546 (*b*), I find the following: "We know that the top of the wheel of a moving buggy goes faster than the bottom." Is this so? How can it be so, when the wheel is in one solid piece?

J. H., Crescentville, Ohio.

ANS.—The following will make it plain to you: Suppose the felloe and tire of the wheel to be removed, leaving the hub and the projecting spokes, as in Fig. 1. If the wheel in this condition is caused to turn, the motion is not exactly rolling, but a series of rotations about the ends of the spokes as they successively come in contact with the ground. Thus, as shown in the figure, the entire wheel is rotating

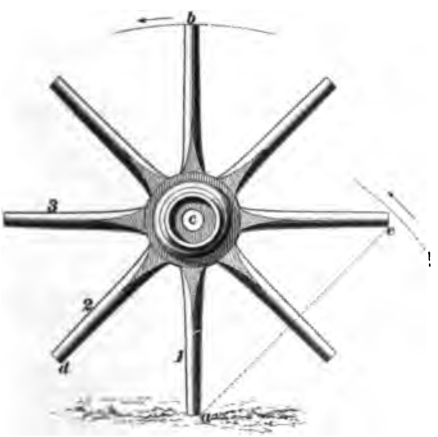

FIG. 1.

about the end *a* of the spoke *1*, which is the only point of the wheel in contact with the ground. In an instant the end *d* of spoke *2* will touch the ground, point *a* will be lifted, and the whole wheel will swing about point *d* as a center. Now, if there were twice as many spokes, the motion would be smoother; and if there were three or four times as many, it would be still smoother. In any case, however, the *character* of the motion would remain the same; that is, the motion would be made up of a succession of short swings about the ends of the spokes. Carrying the matter a little further, it is not difficult to see that a wheel with a rim might be conceived as having a very great number of spokes, the ends of which are very close together. This conception of the wheel with the rim leads at once to the following

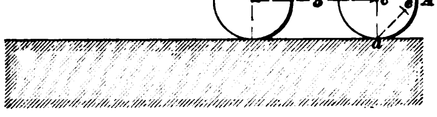

FIG. 2.

important fact: A rolling body rotates as a whole about the point in contact with the ground. Thus, the roller shown at *A*, Fig. 2, is swinging as a whole about the point of contact *a* just as truly as the wheel of Fig. 1 is swinging about the end *a* of the spoke. When a body rotates about a fixed point, or axis, it is easy to find how fast any given point is moving at any instant, and also the direction of its motion. For example, in Fig. 1, *a* is the fixed point; suppose the center *c* of the wheel to be moving 5 feet per second. The point *b* at the end of the upper spoke is twice as far from *a* as from the center *c*, and it is plain that it moves twice as far in the same time, or, in other words, moves twice as fast as the center *c*. The point *e* is about 1.4 times as far from *a* as from the center *c*, and hence it is moving about $5 \times 1.4 = 7$ feet per second. If we wish to find in what direction *e* is moving, we describe an arc of a circle through *e* with point *a* as a center. In the same way, the direction of motion of point *e*, Fig. 2, is determined. There is this difference, however: in Fig. 1, point *e* follows the circular path until the end *d* strikes the ground, while in Fig. 2 the circular arc is the path of the point for only an instant. The speed of any point of the roller of Fig. 2 is found as above shown; thus, the top point *b* moves twice as fast as the center *c*, because it is twice as far from the center of rotation *a*. In general, the speed of any point of a rolling body is exactly proportional to its distance from the point of contact with the ground. The answer to the wagon-wheel question is now apparent. The top of the wheel is, at any given instant, moving twice as fast as the center, and therefore very many times as fast as a point near the bottom of the wheel. This fact may be confirmed by watching the wheel of a rapidly moving carriage; the upper spokes form a blurred maze, while the lower ones can be seen distinctly. That the top of a roller moves twice as fast as the center may be shown by a very old experiment. Take a plank and move it on top of a roller, as shown in Fig. 2. It will be found that when the plank has moved, say 10 feet, the center of the roller has moved just 5 feet, showing that the point in contact with the plank moves twice as fast as the center.

(138) (*a*) In designing a gas engine, in which diameter of piston is 2 inches, stroke 2¼ inches, clearance in cylinder equal to one-half the volume swept through by the piston, what should be the weight of the flywheel, 10 inches in diameter, to give proper compression? The speed must not fall below 200 revolutions per minute. Please give formulas and explain. (*b*) Would cast iron be suitable for the valve seats of this engine, or what is the best metal of which to make them? J. B., Bridgeton, N. J.

ANS.—(*a*) As you do not state whether the engine is of the two-cycle or the four-cycle type, we will assume the latter. The theoretical formula for the weight of the flywheel is as follows:

$$W = \frac{H g}{n^2 E V^2},$$

where
W = weight of flywheel rim in pounds;
g = 32.16, acceleration due to gravity;
n = ratio between mean radius of flywheel rim and length of crank;
E = coefficient of unsteadiness, varies from $\frac{1}{30}$ to $\frac{1}{150}$;
V = mean velocity of crankpin, feet per second;
H = number of foot-pounds that must be stored up by flywheel per working stroke.

The work done on the piston during the working stroke will be about 25 foot-pounds. With a four-cycle engine, at least 80 per cent. of this must be stored to do the work of compression, and carry the engine through the other three strokes. We will therefore take $H = 20$ foot-pounds, and will assume $E = \frac{1}{30}$. From the given data,

$$n = 5 \div 1\tfrac{1}{4} = 4, \text{ and } V = \pi \times \frac{2\frac{1}{4}}{12} \times \frac{200}{60} = 2.18 \text{ ft. per sec.}$$

Substituting in the formula,

$$W = \frac{20 \times 32.16}{4^2 \times \frac{1}{30} \times 2.18^2} = 254 \text{ lb.}$$

You will readily see that this is an excessive weight for a 10-inch wheel. If you make the mean diameter 15 inches, $n = 6$, and the weight required will be $254 \text{ lb.} \times \frac{4^2}{6^2} = 113$ pounds; and, if the diameter is 20 inches, the weight will be $254 \text{ lb.} \times \frac{4^2}{8^2} = 63\frac{1}{2}$ pounds. It would, therefore, seem preferable to use a lighter wheel with a larger diameter. (*b*) Cast iron is the material ordinarily used.

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(139) How are mirrors made? J. R., Woonsocket, R. I.

ANS.—See HOME STUDY MAGAZINE, October, 1898, Answers to Inquiries, No. 418.

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(140) (*a*) Referring to the enclosed sketch, Fig. 2, what is the diameter d of one of the five equal-sized balls that will just fill a cylinder 10 inches in diameter, that is, so that each ball will touch the wall of the cylinder and two other balls? (*b*) What is the diameter of a sixth ball that will touch each of the five balls, and also the plane upon which these balls are resting? F. W. K., Providence, R. I.

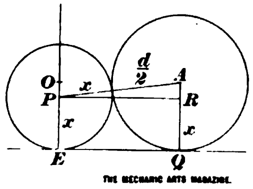

FIG. 1.

ANS.—(*a*) In the right triangle $A\,B\,O$, Fig. 2, the angle $A\,O\,B = a = \frac{1}{10} \times 360° = 36°$.

And $\sin a = \frac{A\,B}{O\,A} = \frac{d}{2\,b}$; therefore, $b = \frac{d}{2 \sin a}$.

Also, $b + \frac{d}{2} = O\,C = \frac{1}{2} D$.

where D denotes the diameter of the cylinder. Therefore,

$$\frac{d}{2 \sin a} + \frac{d}{2} = \frac{D}{2};$$

whence,

$$d = \frac{D \sin a}{1 + \sin a}. \quad (1)$$

Also,

$$b = \frac{d}{2 \sin a} = \frac{D \sin a}{1 + \sin a} \div 2 \sin a = \frac{D}{2(1 + \sin a)}.$$

(*b*) Fig. 2 shows a section through the axis of the cylinder and the center of one of the balls. Let $x = P\,E$ = radius of sixth ball. Then, we have

$$P\,R = O\,A = b = \frac{D}{2(1 + \sin a)};$$

and

$$P\,A = x + \frac{d}{2}, \quad A\,R = \frac{d}{2} - x.$$

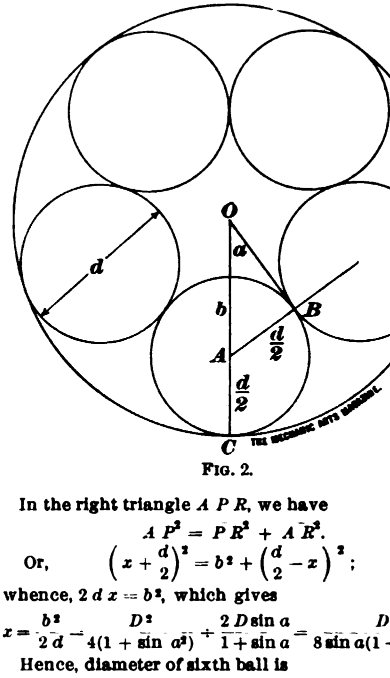

FIG. 2.

In the right triangle $A\,P\,R$, we have

$$A\,P^2 = P\,R^2 + A\,R^2.$$

Or,

$$\left(x + \frac{d}{2}\right)^2 = b^2 + \left(\frac{d}{2} - x\right)^2;$$

whence, $2\,d\,x = b^2$, which gives

$$x = \frac{b^2}{2\,d} = \frac{D^2}{4(1 + \sin a^2)} \div \frac{2\,D \sin a}{1 + \sin a} = \frac{D}{8 \sin a(1 + \sin a)}.$$

Hence, diameter of sixth ball is

$$2\,x = \frac{D}{4 \sin a(1 + \sin a)}. \quad (2)$$

In a table of natural sines we find $\sin a = \sin 36° = .58779$. Using this value of $\sin a$ and putting $D = 10$, we get $d = 3.702$, nearly, and $2\,x = 2.678$, nearly.

***

(141) How will it affect the running of an Armington & Sims engine if the tensions of the springs of the governor are unequal? W. T. G., Providence, R. I.

ANS.—The different parts of the governor are connected in such a way that, theoretically, a difference in the tensions of the springs does not affect the running of the engine; the sum of the centrifugal forces of the two weights is resisted by the sum of the tensions of the two springs, the connections between the two weights forcing all to move together, so that the effect is the same as if but one weight and one spring were used, the centrifugal force and tension of the two being respectively equal to the sums of the centrifugal forces and tensions of the two weights and springs. Practically, an inequality in the tensions will increase the friction of the governor parts, and tend to make the governor less sensitive.

(142) (*a*) Is there any preparation that will dissolve the "scale" which forms on metal when brazing? I use a gasoline brazing furnace, with borax as a flux. (*b*) What is the lightest gauge of Shelby steel tubing $1\frac{1}{4}$ inches in diameter that can be safely used for the frame of a bicycle?

G. C. W., Conesus, N. Y.

ANS.—(*a*) Not that we know of. (*b*) It is impossible for us to say. The weight of tubing suitable for a bicycle frame is best determined by experiment; the history of the bicyle proves this. Manufacturers gradually reduced the weight until they found that they had gone too far, and bicycles were continually breaking down; then they increased the weight slightly. The stresses in a bicycle frame vary so much with the character of the road, weight of rider, and speed attained, that it is impossible by means of figuring to do more than corroborate what experiment teaches. In HOME STUDY MAGAZINE, July and August, 1898, there is an excellent article by Benj. F. La Rue, entitled "Stresses in a Bicycle Frame," that you should read.

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(143) (*a*) In a mine having three sections; with 50 miners in each section; cars to hold $1\frac{1}{4}$ tons; output, 750 tons per day: roads approximately level; what system of haulage will be most economical? (*b*) In a mine using electric haulage, with a voltage of 500, overcompound 10-per-cent. trolley system (600 volts considered fatal), what means would you use to protect persons from shocks, and what would be the result if a person came in contact with the live wire? These questions were given in an examination in 1897. (*c*) What is the meaning of the expression "overcompound?" H. M. McA., McCartney, Pa.

ANS.—(*a*) Electric or compressed-air locomotive haulage, particularly if electricity or compressed air is used about the mine for other purposes. (*b*) The wire should be placed on the rib side, near the roof, or sufficiently high to clear the heads of the men and mules while passing with cars. As an overcompound 10-per-cent. trolley system would never give a higher voltage than $500 + (500 \times .10) = 550$ volts, it would not, therefore, according to the above assumption, be fatal to any healthy person who came in contact with the live trolley wire. (*c*) "Overcompound" means that the generator or dynamo is so wound that the voltage between the terminals increases with an increase of load.

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(144) In my steam launch I have a water pump driven by a $4'' \times 6''$ engine running at 250 revolutions a minute; steam pressure, 100 pounds gauge. The pump has a 1-inch plunger and about $1\frac{1}{2}$-inch stroke; the supply and the feed pipes are $\frac{1}{2}$ inch. When the pressure gets above 50 pounds, the valves of the pump pound very hard. Please tell me how to remedy this. I may add that the pump supplies about the right quantity of water with the present stroke, but the stroke can be altered if desirable; the valves are standard check. R. S. D., Peterboro, Ont.

ANS.—It is probable that the trouble can be remedied by the use of larger check-valves. By using larger valves the lift will be less and they will return to their seats with little if any jar.

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(145) (*a*) How would you proceed to throw a cross-compound engine off the center? (*b*) How would you proceed to set the valves of a boiler-feed duplex steam pump? C. R. D., Lolo, Mont.

ANS.—(*a*) If there is no by-pass valve or other device, by means of which steam can be admitted directly to the low-pressure cylinder from the steam pipe, it will generally be possible, by using the starting bar, to work enough steam into the low-pressure cylinder through the high-pressure cylinder to start the engine. (*b*) There are several sizes and types of duplex pump, varying somewhat in detail; the following general rule, however, which applies equally well to any make of duplex pump, should be sufficient to enable you to set the valves on any size: set the valves so that, just before one piston comes to rest at the end of its stroke, the valve that regulates the admission of steam to the opposite piston will be completely shifted, thus starting that piston on its stroke. By this arrangement, one piston slows down and comes to rest, while its mate is beginning its stroke; the discharge of the pump is thus made nearly uniform, and there is little or no shock. The method of adjusting the valve for any particular pump is generally so obvious that no engineer should have any trouble in setting the valve so as to obtain the motion described.

***

(146) (*a*) What is the effect of too much travel of an air-brake piston? (*b*) Has it anything to do with skidding the car wheels?

A. M. L., Fairmont, W.Va.

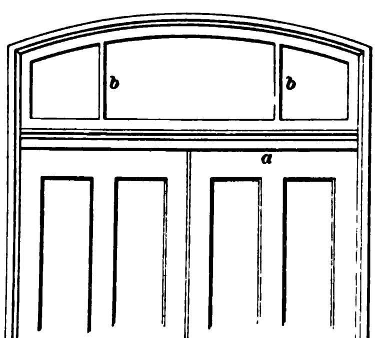
ANS.—(*a*) Increasing the travel of the air-cylinder piston increases the volume of the cylinder, and, as this increased space must be filled by the auxiliary pressure each time a train-line reduction is made, the brake will not set as hard for a given reduction as one that has a shorter travel. Also, increasing the travel decreases the pressure at which the brake cylinder and auxiliary reservoir equalize: hence, the brake will not hold as well as the shorter travel brake, on a full application, either. (*b*) A brake with a long piston travel does not apply as hard as a short-travel brake, and moreover releases earlier, and applies in full later than a short-travel brake; consequently, it has no tendency to skid the wheels. Short travel, on the other hand, is very liable to cause the wheels to skid.

***

(147) (*a*) Do you know of any preparation that will keep leather belts soft? (*b*) What is the proper name for the bar between a door and the transom above? In the enclosed sketch, I have marked by the letter *a* the bar referred to. (*c*) What is the name of the bar in the transom window marked *b*?

J. T. P., Quincy, Ill.

ANS.—(*a*) There are many special preparations on the market. Castor oil is an efficient belt softener. Read "In the Workshop," in the April number of



THE MECHANIC ARTS MAGAZINE; it contains some useful practical hints about the care of belting. (*b*) The bar or mullion *a* is *itself* properly the transom. The sash above is called the *transom* sash because it rests on the transom. (*c*) The bars *b* are called *sash bars* or *astragals*.

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(148) Which of the following methods of forcing water into a tank requires the most power—up through the bottom of the tank, or up over the top of the tank? J. B. B., Cromwell, Conn.

ANS.—If you force water into the bottom of the tank

you will want a check-valve, which means extra work and expense. And, even when surrounded with a strainer, more or less fine dirt will get into it and cause leakage. More power will be required to put the water in over the top of the tank, for it all has to be lifted higher than the top, whereas, when entering the bottom, none of it has to be lifted that height. Speaking generally, however, one would at once say, put it in over the top. In any particular case, there might or might not be practical reasons against doing so, but it is better, where possible, to do so, for there is then no valve to keep tight.

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(149) (*a*) What is the horsepower of a Hamilton-Corliss condensing engine of the following dimensions: diameter of cylinder, 12 inches; stroke, 42 inches; revolutions per minute, 78; steam pressure, 80 pounds gauge? (*b*) What is the horsepower of the same engine non-condensing? Give method of computing the above. C. C. K., Leroy, Ill.

ANS.—(*a*) The general formula for calculating the indicated horsepower of a steam engine is

$$\text{I. H. P.} = \frac{PLAN}{33{,}000},$$

in which P = mean (average) effective pressure of steam in cylinder in lb. per sq. in.;
L = length of stroke in feet;
A = area of piston in square inches;
N = number of strokes per minute.

The mean effective pressure P may be found by means of an indicator diagram, or it may be calculated approximately when the steam pressure, back pressure, and cut-off, or its reciprocal, the ratio of expansion, are known. The formula for calculating the mean effective pressure (M. E. P.) is

$$\text{M. E. P.} = \frac{.9\,P(1 + 2.3 \log e)}{e} - .9\,p,$$

in which P = absolute steam pressure (= boiler pressure + 14.7 pounds);
e = ratio of expansion (= 1 ÷ real cut-off);
p = absolute back pressure.

For condensing engines with condensers in good order, p may be taken as 3 pounds per square inch, and 17 pounds for non-condensing engines. In order to apply this formula to your example, we must assume a value for e; assuming the horsepower to be rated on real cut-off of $\frac{1}{4}$, e becomes $1 \div \frac{1}{4} = 4$. Substituting this and the values given in your statement, we have, for the condensing engine,

$$\text{M. E. P.} = \frac{.9 \times 94.7\ (1 + 2.3 \times \log 4)}{4} - .9 \times 3$$

$$= 48 \text{ lb. per sq. in., nearly.}$$

The area of a 12-inch piston is $12^2 \times .7854 = 113.1$ square inches; substituting the known values in the formula for I. H. P., we have, for the condensing engine with $\frac{1}{4}$ cut-off,

$$\text{I. H. P.} = \frac{48 \times 3.5 \times 113.1 \times 156}{33{,}000} = 89.8 \text{ H.P.}$$

(*b*) Assuming 17 pounds per square inch as the back pressure, the mean effective pressure is

$$\text{M. E. P.} = \frac{.9 \times 94.7\ (1 + 2.3 \times \log 4)}{4} - .9 \times 17 = 35.5 \text{ lb.}$$

per sq. in.; and the indicated horsepower is

$$\text{I. H. P.} = \frac{35.5 \times 3.5 \times 113.1 \times 156}{33{,}000} = 66\tfrac{1}{4} \text{ H. P., nearly.}$$

***

(150) In many machine shops, brown prints are used instead of blue prints; the paper is, I believe, called "brown-process paper." Can you tell me where I can get it, and about what it costs? I have been unable to purchase it at any of the stores here, and I think that perhaps I have called it by a wrong name. A. W., Providence, R. I.

ANS.—Process papers to produce dark lines upon a light ground can be obtained from any dealer that keeps a full line of architects' and engineers' supplies; the price is about 20 cents a square yard. Write to the Keuffel & Esser Co., New York, or to the Frost & Adams Co., of Boston. A description of the process and method of preparing the paper will be found in HOME STUDY MAGAZINE, November, 1898, article entitled, "The Duplication of Drawings."

***

(151) How do you find the area of the shaded portion in the enclosed sketch, for any height x? R. K., Alameda, Cal.

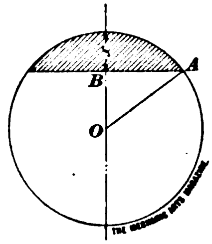
ANS.—Let R = radius of circle;
D = diameter of circle (= 2 R);
n = number of degrees in the angle $A\,O\,B$;
A = the required area;
π = ratio of circumference to diameter.

Then, we have $\cos n^\circ = \frac{R - x}{R}$; (1)

$$A = R^2 \left\{ \frac{\pi n}{180} - \sin 2n^\circ \right\}; \qquad (2)$$

and approximately $\pi = 3.1415927$. (3)

Or, to four places of decimals, $\pi = 3.1416$.



Equation (1) determines n, and then equation (2) gives A the area of the segment exactly. When the segment is not very large, its area is more easily computed from the following very excellent approximate formula:

$$A = \frac{4}{3} x^2 \sqrt{\frac{D}{x} - .608}. \qquad (4)$$

If the radius is 100 inches, and the height x is 2 inches, the exact formula (2) gives $A = 53.16$ square inches; while formula (4) gives $A = 53.17$ square inches. If the radius is 100 inches and the height x is 50 inches, the exact formula (2) gives $A = 6{,}141.84$ square inches; while the approximate formula (4) gives $A = 6{,}139.13$ square inches. Using formula (4), to find the area of a semicircle whose radius is 100 inches, we get 15,753.65 square inches, whereas the correct area is 15,707.96 square inches.

***

(152) What is the composition of the sticky stuff that is used on "Tanglefoot" fly paper, and how is it applied to the paper? J. W. M., Chicago, Ill.

ANS.—We believe that either of the following two recipes will answer the purpose: (1) Resin 8 parts, turpentine 4 parts, rapeseed oil 4 parts, and honey $\frac{1}{2}$ part. (2) Resin 1 pound, molasses $3\frac{1}{4}$ ounces, and linseed oil $3\frac{1}{4}$ ounces. Boil either one of the above mixtures until thick enough, and then coat the paper with it

***

(153) (*a*) I have made a horseshoe from an old file, and now I want to know how to magnetize it. Kindly explain. (*b*) If it has to be wound, please explain the manner of winding, and how the wires should be attached to a dynamo. We have both arc and incandescent lights. L. T. M., Lakeland, Fla.

ANS.—(*a*) and (*b*) The steel must first be made glass-hard by heating to a cherry red and quenching in water. Then wind both limbs with several layers of insulated wire of about No. 18 size, first wrapping the steel with several layers of paper or cloth, to provide insulation. The winding over the two limbs must be in opposite directions, in order that one pole may become a north, the other a south, pole. Connect this winding in series with a 16-candlepower 110-volt incandescent lamp. Another method of magnetizing is to draw the steel across the poles of an electromagnet.

SELF HELP

CHARACTER IS CAPITAL.

CHARACTER is the poor man's capital. Great men have found no broad, rose-strewn royal road to their triumphs. Their road has been the old beaten road, by way of industry and perseverance. A constant struggle, a ceaseless battle to bring success from inhospitable surroundings, has been at all times the price of great achievements. The man who has not fought his way up to his own loaf, who does not bear the scar of desperate conflict, cannot know the meaning of success.

When James A. Garfield was elected United States Senator from Ohio, in January, 1880, President Hinsdale of Hiram College, Ohio, addressed the students in a speech appropriate to the occasion—when high honor had been done an alumnus of the college, a man who had been, in the course of his eventful career, first, bell ringer, and then President of the institution. President Hinsdale said among other things: "General Garfield once rang the school bell when a student here. That did not make him the man he is. Convince me that it did, and I will hang up a bell in every tree in the campus and set you all to ringing. Thomas Corwin, when a boy, drove a wagon, and became head of the treasury; Thomas Ewing boiled salt, and became a senator; Henry Clay rode a horse to the mill from the Slashes, and became the great commoner from the West. But it was not the wagon, nor the salt, nor the horse that made these men great. These are interesting facts in the lives of these illustrious men. They show that in our country it has been and still is possible for young men of ability, energy, and determined purpose to rise above lowly conditions and win places of usefulness and honor. Poverty may be a good school; straightened circumstances may develop power and character; but the principal conditions for success are in the man himself, and not his surroundings."

While the future President of the United States was yet an infant, his mother was left a widow. She was a woman of unusual energy, faith, and courage. Declaring that her children should not be separated, she kept them at home, together, till they were able to take care of themselves. Garfield's boyhood did not, as President Hinsdale well puts it, differ materially from the boyhood of other youths in his neighborhood. "He chopped wood, and so did they; he hoed, and so did they; he carried butter to the store in a little pail, and so did they. Other families that had not lost their heads naturally shot ahead of the Garfields in property, but such differences counted for less than they do now."

While still a mere lad, young Garfield's intense desire to earn a little money led him to become a boatman on the Ohio canal, which passed within easy distance of the Garfield farm. The humble duties of this trying and laborious position he discharged with so much fidelity and diligence that he was promoted to the loftier position of steersman of a barge.

We next find him a sailor, on one of the schooners plying Lake Erie, but illness compelling him to relinquish this mode of life, he returned home to tell his good mother of ambitious plans for the future. He had already acquired the foundation of an education in the ordinary branches of learning, and upon this foundation resolved to build a loftier structure than his surroundings would seem warranted in promising. With the very scanty saving within his reach, and by his mother's assistance, he began a course of study at an obscure institution, known as the Geauga Academy, not far from Orange, Ohio.

Too poor to pay their board in the village, young Garfield and his roommate rented an apartment in an old farm building not far from the academy, and there did their own cooking and housekeeping in the most primitive way. The future President had, however, a stout heart and a determined will. With honest and unremitting toil he applied himself to the task before him. He found work among the village carpenters, and spent his mornings, evenings, and Saturdays in their shops, where willing hands helped out the boy on his rugged path. By teaching a district school in winter he added a little to his scanty income. So for several

years, teaching in winter, working at odd times at the carpenter's bench, and attending the fall and spring terms of the academy, he secured the training necessary for a higher collegiate course. Tall, muscular, browned by wind and exposure, sound in every fiber of his body, a strong athlete, and a good student, this fair-haired country boy became a great favorite with his associates.

Admitted in the fall of 1854 to the junior class of Williams College, Williamstown, Mass., Garfield devoted himself with energy to his studies, and very soon acquired a reputation for scholarship far above that of any of his fellow students. He was graduated in 1856, carrying off the honors of his class in metaphysics, an enviable distinction.

Three years later, after having taken successful part in political campaigns in Northern Ohio, he was nominated by the Anti-Slavery party for State Senator, and elected by a substantial majority.

In the early years of the Civil War, Garfield won such distinction in the field as to entitle him to promotion, first as brigadier-general, and then as major-general. But while he was bravely fighting in the field, his fellow citizens of Ohio did not forget him. Elected to the National House of Representatives, Garfield, by the advice of President Lincoln and Secretary Stanton, resigned his major-generalship on the 5th of December, 1863, and two days later took his seat in the House of which he was so long to remain an honored member.

Garfield was, as already stated, elected in January, 1880, to fill the Senatorial chair, to to be relinquished on March 4, 1881, by that illustrious democrat, Allen G. Thurman. Before, however, General Garfield could qualify as Senator, he was, in 1880, by the Republican party of the nation, nominated and elected to the Presidency.

The universal acclaim of a proud and confiding people which greeted him on his accession to office, and the profound world-wide grief that marked his untimely taking off, it is needless here to recite. Garfield has left a noble name in American history. No man's career better illustrates the truth that "Character is the poor man's capital."

The best education in the world is that got by struggling to get a living. What is defeat?—Nothing but the first step to something better.—*Wendell Phillips.*

Men of character are the conscience of the society to which they belong.—*Emerson.*

RESOLUTE DETERMINATION.

"I CAN'T; it is impossible," said a lieutenant to Alexander. "Be gone!" shouted the conquering Macedonian, "there is nothing impossible to him who will try."

Were we called upon to express in one word the secret of so many failures among those who started out in life with high hopes, we should say, unhesitatingly, that they lacked will power. They could not half will. What is a man without a will? He is like an engine without steam—a mere sport of chance, tossed about hither and thither, always at the mercy of those who have wills. Strength of will is the test of a young man's possibilities. Can he will strongly enough, and hold whatever he undertakes with an iron grip? It is the iron grip that takes the strong hold on life.

What chance is there in this crowding, pushing, selfish world, where every one is pusher or pushed, for a young man with no will, no firm decision? "The truest wisdom," said Napoleon, "is a resolute determination." An iron will without principle might produce a Napoleon; but with character it would make a Wellington or a Grant, untarnished by ambition or avarice.

History is full of examples of men and women who have redeemed themselves from disgrace, poverty, and misfortune, by the firm resolution of an iron will. The consciousness of being looked upon as inferior, as incapable of accomplishing what others accomplish, the sensitiveness at being considered a dunce in school, has stung many a youth into a determination which has elevated him far above those who laughed at him, as in the case of Newton, of Adam Clark, of Sheridan, Wellington, Goldsmith, Dr. Chalmers, Curran, Disraeli, and hundreds of others. "Whatever you wish, that you are; for such is the force of the human will that whatever we wish to be, seriously and with a true intention, that we become." While this is not strictly true, yet there is a deal of truth in it.

It is men like Mirabeau, who "trampled upon impossibilities;" like Napoleon, who did not wait for opportunities, but made them; like Grant, who had only "unconditional surrender" for the enemy, who change the front of the world. "We have only what we make, and every good is locked by nature in a granite hand that sheer labor must unclench."

A man who can resolve vigorously upon a course of action, and turn neither to the

right nor to the left, though a paradise tempt him, who keeps his eye upon the goal, whatever distract him, is sure of success. Given a knowledge of one's will power, it would be comparatively easy to predict whether he would make of life a success or a failure. Men like Sir James Mackintosh, Coleridge, La Harpe, and many others who have dazzled the world, but who never accomplished a tithe of what they attempted; who were always raising expectations that they were about to perform wonderful deeds, but who accomplished nothing worthy of their abilities, have been deficient in will power. One talent with a will behind it will accomplish more than ten without it.

READINESS AND FIDELITY.

A GENTLEMAN who was being driven about the streets of a small but prosperous New England town made the remark, as his host pointed out a neat engine house with the apparatus all in readiness for instant use, that it would hardly pay to keep firemen in constant readiness for duty in so small a place, where a fire of any importance seldom broke out.

"We thought the same things ourselves, five years ago," replied his host. "We fancied we should get along if we had a good steam fire-engine and kept it near the center of the town, where our volunteer department, or any competent persons, could readily get at it in case of fire. We also kept a pair of horses for use with the engine at a nearby livery stable. For a time the arrangement worked beautifully, and the town saved money for the simple reason that there happened to be no fires worth mentioning. Then, all of a sudden, in the dead of a sharp winter night, a fire broke out in our lumber district, spread to the business section of the town, and swept everything before it, because it got such a tremendous start before met by any effective opposition. Nearly all the business part of the town was wiped out, and the loss mounted up into the hundreds of thousands. After that experience we did not want any more cheap fire protection; and long before our business section was rebuilt, we had in the city's employ a paid fire-department equal to any in the state. Within the past four years there have been three threatening fires in the lumber district, but our firemen were on the ground within seven minutes after the first stroke of the alarm, and not one of those fires, nor any other, has been able to get a dangerous start since we began to realize the value of readiness."

The lesson that this enterprising little city learned so effectively and obeyed so promptly is one equally important to every individual. The only real safety lies in sleepless and unremitting caution that presents to danger, moral or physical, a constant front of readiness. The happy-go-lucky method will never do either to build up character or ward off misfortune.

It is the initiative that counts. Once let a weakness get a foothold or a headway, and it becomes exceedingly difficult to dislodge it. We must smother it at the outset, conquer it before it gets a devouring hold of body and soul, just as the watchful, prompt, and trained fire department gets control of an incipient fire. The instant the alarm comes we must be ready to fight the aroused evil tendency, the wrong desire, the insidious temptation. Everything depends upon the promptness of our resistance to evil. Any dallying with it, any lingering to make deferred preparation, any moral confusion or hesitation arising from not being prepared, is destructive tc character.

A great steamship was crossing the ocean. The mighty engines throbbed steadily day and night. The engineer and his assistants had never for a moment left their posts, although it had been days since any signal had come to them from the pilot house. Suddenly the great gong in the engine room sent forth its sharp clang. Stop! In an instant the steam was shut off and the machinery ceased its throbbing. Clang, Clang! Reverse the engines! The big levers are thrown over, the piston rods move, and the wheels revolve the other way. The mighty ship has escaped collision with an iceberg that suddenly looms up out of the fog, by the faithful readiness of those men in the engine room. What if they had left their places for just a minute in the seeming security of mid-ocean? What if obedience to that first, sudden, unexpected signal from the pilot house had been delayed for a single moment? How many precious lives might have been lost, how much treasure swallowed up by the insatiable sea, how much suffering inflicted upon hundreds of souls all over the world, how much human confidence destroyed! Think of the peril, all unseen, undreamed of, if the chief engineer had left his place for a minute, just before the gong had struck.

The value of fidelity is clearly illustrated by the career of Professor Morris, head of

the mechanical department, Cornell University. It is related of Professor Morris that one day he greeted an unexpected visitor in these terms:

"Ah, Mr. Depew, I am glad to see you, for I claim you as an old acquaintance."

"How's that?" queried Mr. Depew.

"I used to work for the New York Central," was the Professor's reply.

"Indeed! In what department?"

"Oh, just in the ranks."

"How did you get on there?" asked Mr. Depew.

"I was just a fireman on an engine. That was a tough job, but it led up to the position of engineer. I made up my mind to get an education. I studied at night and fitted myself for Union College, running all the time with my locomotive. I procured books and attended, as far as possible, the lectures and recitations. I kept up with my class, and on the day of graduation I left my locomotive, washed up, put on gown and cap, delivered my thesis, and received my diploma; put gown and cap in the closet, put on my working shirt, got on my engine, and made my usual run that day."

"Then," said Depew, "I knew how he became Professor Morris. It was simply by doing each duty faithfully as he came to it, and preparing for the next."

BE MASTER OF THE SITUATION.

THE aim of education is a man capable of the largest amount of service to others and of the largest amount of personal happiness. Both of these elements in the end of education are determined by a knowledge of the civilization of the age and country in which the pupil is born and in which he is to live, together with a knowledge of the pupil himself, both mental and physical. The knowledge, power, and habits that would fit a child for a happy and useful life in one country would not in all respects fit him to live in another.

"The crowning fortune of a man," wrote Emerson, "is to be born to some pursuit which finds him in employment and happiness, whether it be to make baskets, or broadswords, or canals, or statues, or songs."

One of the most painful and pitiable objects in the world is a human being so fearfully and wonderfully made, carefully adapted to accomplish some particular good, and yet doing imperfectly and unhappily some other thing which Providence had adapted some one else to perform.

The world does not demand of any one in particular that he be a lawyer, a minister, a doctor, a farmer, or a merchant; it does not dictate what any one in particular shall do; but it does demand that he do *something* and that he be *master* in whatever he undertakes. The world will applaud the man who is master of the situation—for he is a king in his line. For him all doors shall fly open. But for the botch and the failure, the world has no mercy.

Sidney Smith declared: "Be what nature intended you for, and you will succeed; be anything else, and you will be ten thousand times worse than nothing."

THE MAN OF SIMPLE DUTY.

THE machinery had come to a standstill throughout a great mill. Instead of the steady whir of wheels, the sound of swiftly moving shafts, and the hum of belts, all was silent. Each workman raised from his bending posture, looked at his neighbor, and wondered what was wrong. It was not dinner time—the hands of the clock showed that. Work was not lacking—many orders were on the files. Machinists were not wanting—every one was at his post.

What, then, was the trouble? The foreman hastened down to the engine room.

"What's wrong, Joe?"

"Only a broken cog, sir. I heard a strange sound all at once; then there was a hitch as the wheel went round, and I saw that we must stop. It will take an hour to repair the damage. A new wheel must be put in."

An hour, during which all the shop must wait. An hour's delay in filling important orders. Some one would be disappointed in not receiving work promised on time. All because a cog had been broken.

* * *

An old man was sweeping the steps of a state building.

"Do you not get tired of this sweeping, day after day?"

"Why, no. Some one must do it. Why not I?"

He was a cog in the machinery.

* * *

In a great steel foundry it was the duty of one man to watch the seething kettle of white-hot metal, and as the dross rose to the top, to skim it quickly away. Nothing else. And yet the value of that metal depended upon the fidelity with which this man did his work. Pure steel must contain no dross.

* * *

A railway train runs into a depot. Hardly has it come to a standstill when the sharp

clang of the hammer is heard striking. one after another, the wheels under each ca. If the ring is clear and unmistakable, the trained workman knows that all is right. On the other hand, if the sound be dull and cracked, he is sure that there is a broken wheel. It is his duty to report the fact at once. Life depends upon the manner in which he strikes those wheels.

* * *

Are such lives narrow, dwarfed, and weak? Civilization demands from every man, in every place, that he shall do his simple duty. "Only a cog in the wheel." What would the wheel be without those cogs?

"DO YOU WANT A JOB?"

SOME years ago, perhaps thirty or more, a little lad was loitering along the streets of an interior city. As he passed the shop of a local photographer, a man came out and spoke to him.

"Do you want a job?" he asked.

The boy said promptly, "Yes, sir."

"If you get it, will you attend to it?" the man asked.

Again the answer was, "Yes, sir."

"It is not a lively one. You have to sit still and watch things," the man said. "Do you think you can keep awake?"

"I can try, sir," the boy said, and after a little more talk he got the job.

It was not a lively one. He had to sit upon a housetop and watch a lot of photographic negatives to make certain that they got just enough light—not too much. He did the work well. The photographer never caught him napping, no matter how suddenly he came upon him. In a little while he showed that he was as intelligent as he was trusty. Then the photographer noticed that the lad's clothes, though worn, were always clean and neatly mended. A little inquiry proved that the new boy was the son of a widow who had very little besides her children. The little her son earned was a very material help to her. She was eager to have him in school. He had been there, all told, less than two months, but she could not send him any longer; he had neither the time nor the clothes for it.

Sitting aloft day after day, the lad fell to studying the heavens. Chance had thrown into his hands a volume on astronomy. At first he found it dry reading, but the study of it had, in a little while, redoubled his interest in his ever-beloved sky. He longed above everything for a telescope, to enable him the better to search out its glories and its mysteries. By the help of his kind employer he at length rigged up an apology for one—something whose limited powers served only to whet his appetite for real telescopic revelations.

He began to go to Sunday school. His teacher there grew interested in him and his ambition. Through her aid and counsel, joined to that of other friends, he went seriously to work to secure the coveted instrument. A second-hand one was offered to him for $200. He sent for it, but found it so unsatisfactory that he returned it. Expressage both ways cost him $20, which he could very ill spare. However, he got the money's worth in experience that determined him to be satisfied with nothing less than a telescope of the very first class.

To get money for such a one he worked and saved. A shabby coat had no terrors for him if the shabbiness meant something towards the desire of his heart. Pretty soon he was able to buy a telescope of the very best pattern, with a five-inch refractor. When it was duly in position upon the roof, where he had spent so many working hours, he was one of the happiest young fellows in the world.

His friends were almost as happy—particularly that friend who had given him the aerial job. The roof became a favorite resort for everybody in the city who had the least hankering after a sight of the stars. The young owner of the telescope was glad to let them look. As for himself, he nightly scoured the heavens, noting and recording by means of drawings the many wonderful things he saw there.

Besides a good telescope, he had phenomenally keen sight. That is evidenced by the fact that with this five-inch refractor, an instrument below the first power, he discovered and described a dozen comets. Providence had, perhaps, put it into the mind of a rich man to offer prizes for just such discoveries. They were not large prizes, but altogether this self-taught astronomer won enough to give him a welcome thousand dollars.

He had, however, rebuffs as well as helps from the big outside world. The American Association for the Advancement of Science met in his native city not long after he had begun his study of the heavens. He was presented to its president, Simon Newcomb, and began modestly to speak of what he had done and hoped to do.

"Humph! You had better put away that telescope! It is too big, anyway. You can

do nothing with it; you had better study mathematics than waste your time star gazing," said the great man. The beginner left him half heart broken. But after the first smart he resolved that he would study mathematics, and he did.

Time's whirligig brings some revenges that are precious. Fifteen years later Prof. Simon Newcomb writing to Prof. Edward Emerson Barnard, upon whom Vanderbilt University had conferred the degree of Doctor of Science, and whom the Royal Astronomical Society of London has been proud to make a Fellow, asked if Prof. Barnard "knew anything of a young fellow with a telescope, who had lived in Nashville when the Association for the Advancement of Science met there?" and added, after some further inquiry, "It cannot be possible that you are the one I mean?"

It was not only possible, but actual. Prof. Barnard, today the foremost of American astronomers, who has mastered not merely mathematics but the whole college course, who has discovered more comets than any other living man, and who has mapped and measured the fifth satellite of Jupiter, is the lad who made the beginning by faithfulness over few things upon the roof of a Nashville photograph gallery.

How true the saying of Lilian Whiting: "Success in life—the only success in its true sense—lies in its quality of living day by day, and not exclusively in its achievements, and still less in its acquirement of possessions. We can live in aspirations, in good will, in generosity, in love, amid the most limited, narrow, and trying circumstances." Success means fidelity to duty, with benevolent regard to our fellows.

What shall I do to be forever known?
Thy duty ever!
This did full many who sleep all unknown—
Oh, never, never!
Think'st thou, perchance, that they remain unknown
Whom thou know'st not?
By angel trumps in heaven their praise is blown,
Divine their lot.

THINKING DOES THE DEED.

BE IT known that that person is educating himself the best, other things being equal, whether in school or out, in law office, store, shop, or on farm, who is adhering with the most rigid exactitude to the mandates of his physical, mental, and moral needs in intense and persistent thinking. It is *thinking* that does the deed.

STUDY NECESSARY FOR SUCCESS.

MORE intellectual athletes are starting in the race of life, today, than ever before. The chances of success are diminished in proportion, for the supply is constantly encroaching on the relative demand. The members of the professions, the merchants, the mechanics, the farmers, who shall enter our places in the twentieth century, must be better men than we of the nineteenth, or they will fail. The law of the "survival of the fittest" will be applied to those of the twentieth century with more merciless severity than ever it has been to their predecessors. There is less room than ever before for "dead beats" and "bummers." Moral results are reached by railroad and telegraph in our time. The Greeks have told us that "the mills of the gods grind slow"; but they move faster as the world grows older. If in these our times one chooses to become a loiterer, sensualist, or sluggard, the mills will grind time to powder with a rapidity and thoroughness that the framers of the old Greek proverb never conceived.

If such is the necessity laid on us for growth and development, what are some of the conditions through which they are reached?

One important condition of growth is keenness and activity in observation of the phenomena of daily life. It is not enough that a man be mentally active in the calm of a library alone. He must think in the street and the shop, in the noisy court room and the crowded exchange. The successful student, as well as the man of affairs, must be constantly alive to what may not be inaptly called the molecular action of society. He must seize, classify, and formulate the results obtained, so that they may always be ready to inform the judgment and give precision, directness, and force to the action of the will. Thus also one makes his own the common sense and common judgment of the average man—always specially useful to one who is a student of progress in mechanical lines. This activity of observation must be formed into a habit and made a part of your very being.

The world generally gives its admiration, not to the man who does what nobody else ever attempts to do, but to the man who does best what multitudes do well.—*Macauley.*

The man who resolves to do one thing honorably and thoroughly, and sets about it at once, will attain usefulness and eminence.—*E. P. Roe.*

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

IN THE INTERNATIONAL CORRESPONDENCE SCHOOLS,

SCRANTON, PA.

ORE SORTER INSTALLS A MINE LIGHTING PLANT.

Having some practical knowledge of electricity, I enrolled in The International Correspondence Schools.

The Course certainly gives a good, common-sense theory of the inner working of dynamos and electrical machinery in general. Since studying in the Course, I have helped install a lighting plant in the El Paso Gold King Mine, in Cripple Creek, at which place I am regularly employed as ore sorter. The Course, while simple, is very complete. I consider the mathematics alone worth ten times the amount charged for the Course.—*Chas. G. Bower (J. 1213), Cripple Creek, Colo.*

CHIEF ENGINEER OF A LARGE PLANT.

Any words or statements that I can make will fail to properly show my appreciation of the benefits derived from the Stationary Engineers' Course of The International Correspondence Schools.

When I consider the fact that my early education consisted of just three terms of winter school in a country district, and the rest, previous to my Course with the Schools, what I picked up myself during leisure hours, and that I have had to earn my own living since I was 12 years of age, it is with a feeling of gratitude that I recall the poor, homeless boy, kicked about from pillar to post, who has now become chief engineer of one of the largest mills in the South, through the Schools and their splendid method of teaching.—*A. H. Strong (H. 74), Charlotte, N. C.*

TELEPHONE MANAGER GREATLY BENEFITED.

I cannot say enough in praise of The International Correspondence Schools and what they have done for me. The Course has been full of pleasant surprises to me, as I have found it far better than I had expected from the description in the Circular of Information.

For the benefit of my skeptical friends, I would say that they can not only learn a great many new things from the Schools but they will also find out how little they really know regarding matters on which they thought themselves well informed.

I wish to thank the Schools for their attention to my personal needs. The knowledge I have obtained through the Course has been of great practical benefit to me in my position as manager of the Painsville Telephone Company.—*E. T. Grauel (M. E. 6163), Painsville, O.*

APPRENTICE STEAM FITTER BECOMES A SALESMAN.

I have derived great benefit from my Course in the Schools. The interest taken in the scholars seems almost incredible, when the enormous amount of correspondence handled by the Schools is taken into consideration.

I began work as a helper in a steam fitting shop. The knowledge gained through the Course in Plumbing, Heating, and Ventilation has qualified me for the position I now hold as salesman with one of the largest manufacturers of plumbing and heating goods in Chicago.—*R. E. Dewey (P. 33), Rockford, Ill.*

DRAYMAN BECOMES MANAGER AND DRAFTSMAN.

I have had a hard struggle to obtain an education, as I was obliged to go to work when quite young.

Being very ambitious to advance myself, I bought textbooks and studied at night. I first learned the carpenter's trade; then served a three-year apprenticeship at the plasterer's trade; and finally took a position as drayman and clerk in a lumber yard. A year ago I enrolled in the Schools, and made more progress in that year than in five years previous, and at much less cost. I am now manager of the yard and my salary is doubled. I also make all the plans used in this city, including residences and store buildings ranging in value from $700 to $4,000. The system of the Schools is all right for any one with push and energy.—*D. C. Fairfield* (*A. 1799*), *Unionville, Mo.*

FROM MINER TO MINE SUPERINTENDENT.

I can heartily recommend the system of instruction of the Schools to any one who can read and write

and wishes to better his position and salary through study and perseverance. I enrolled in The International Correspondence Schools on the 16th of October, 1891, being their first student in the Complete Coal Mining Course. At that time I was driving headings in a mine. Ten months later I received a state certificate as foreman, and secured a position as assistant mine foreman. This I held for one and one-half years, when I obtained a position as mine foreman, and six months later was given charge of both the inside and outside of the mine where I was employed. This position I have held nearly four years, my salary having been increased 40 per cent. since I began my Course.—*Thomas Coates* (*C. M. 1*), *Yatesville, Pa.*

SCHOOLBOY BECOMES A DRAFTSMAN.

I have been very much pleased at the practical results of my Course in Mechanical Drawing in The International Correspondence Schools. After graduating from the high school at home, I asked the principal of the school where

any one who was unable to go to college could obtain a knowledge of mechanical drawing. He said he considered the "Scranton School Courses" the best way of obtaining it. I accordingly enrolled on the 31st day of July, 1897, and received my Certificate of Proficiency in less than six months. I was able to obtain a position by merely showing the drawings made in my Course. I have since enrolled in the Complete Mechanical Course and am making good progress in the same. The knowledge of mechanical engineering thus gained, combined with my work as draftsman, is certain to bring advancement.—*Carl W. Gage* (*M. D. 1014*), *Groton, N. Y.*

IS NOW IN ELECTRICAL BUSINESS FOR HIMSELF.

I cannot speak too highly of the merits of the system of education of The International Correspondence Schools.

My connection with the institution has been of very great benefit to me. I enrolled in the Wiring and

Bellwork Course on the 31st of January, 1898. By studying in spare time I completed my Course and received a Certificate of Proficiency on the 21st of September, 1898.

I am now in business for myself, being a member of the Carlisle Cycle Company. We deal in bicycles, sporting, and electrical goods, and do a general wiring and repair business.—*John S. Gingrich* (*J. B. 23*), *Carlisle, Pa.*

The Mechanic Arts Magazine.

Extracts from Letters to the Editor.

Every number of THE MECHANIC ARTS MAGAZINE seems to me to be better than the one previous; at any rate, it grows more and more interesting and instructive to me every month. The articles are so well chosen and are written in such a lucid manner that I should think the magazine is bound to be a great success. W. H. E., New Haven, Conn.

I might say, before closing, that taking THE MECHANIC ARTS MAGAZINE all around, I have never seen its equal; it seems to contain all that is essential to the making up of a man.
WILFRED E. WETMORE,
Boys' Industrial Home, St. John, N. B.

I consider THE MECHANIC ARTS MAGAZINE the best publication for young men and women of inquiring and mechanically inclined minds that I have ever seen, and I read most that are published. Its selections of articles are admirable, as only such are selected as are of vital, present interest, and all are easily read and understood by people of average intelligence. It is peculiarly happy in avoiding mathematical problems and solutions. My son, of seventeen years, said the other day as he finished the last number: "This magazine is more interesting than a novel; everything is so concise and plain." You could not receive higher praise. One of the articles on the hydraulic ram, in a back number, has furnished him with great amusement in reading and rereading it and making experiments. It is the simplicity of the language used and the absence of high-sounding words and expressions that make your magazine valuable and readable. The magazine is more than "satisfactory"; it is the *most* satisfactory one I know of for the purpose for which it is published. W. M. BROWN,
May 26th, 1899. Albany, N. Y.

I would be very glad to take the agency for THE MECHANIC ARTS MAGAZINE, as I am largely acquainted here, and think I can do something for you; at any rate I would like to try. I like the magazine very much, and intend to continue as a subscriber. EDWIN W. HAMER,
Brownsville P. O., Yuba Co., California.

I am pleased with THE MECHANIC ARTS MAGAZINE. The establishment of regular practical departments, and instructive and explanatory articles continued from number to number, is better than dividing the series in periods far between. Your Good Schemes department is a good plan.
SAMUEL GIBEAU, Register of Deeds,
Red Lake Falls, Minn.

In remitting my subscription for THE MECHANIC ARTS MAGAZINE, allow me to congratulate you on the marked progress of your magazine. The headway it is making in popular estimation affords a splendid criterion of its excellence, and I consider it fully deserving of the success it has attained. With best wishes for, and every confidence in, its future prosperity, I remain yours truly, W. A. JEFF,
Hunterville, New Zealand.

I have had two numbers of Volume IV of your fine magazine, THE MECHANIC ARTS MAGAZINE, and consider the May number is itself worth $1.00 to any one engaged in a mechanical pursuit. Wishing you success in the grand work of illuminating the workman's path by the lamp of knowledge, I am very truly yours, LINWOOD C. PLUMMER.
Box 243, Fort Fairfield, Maine.

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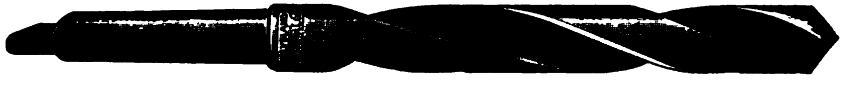

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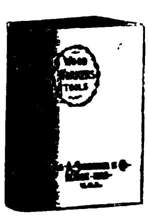

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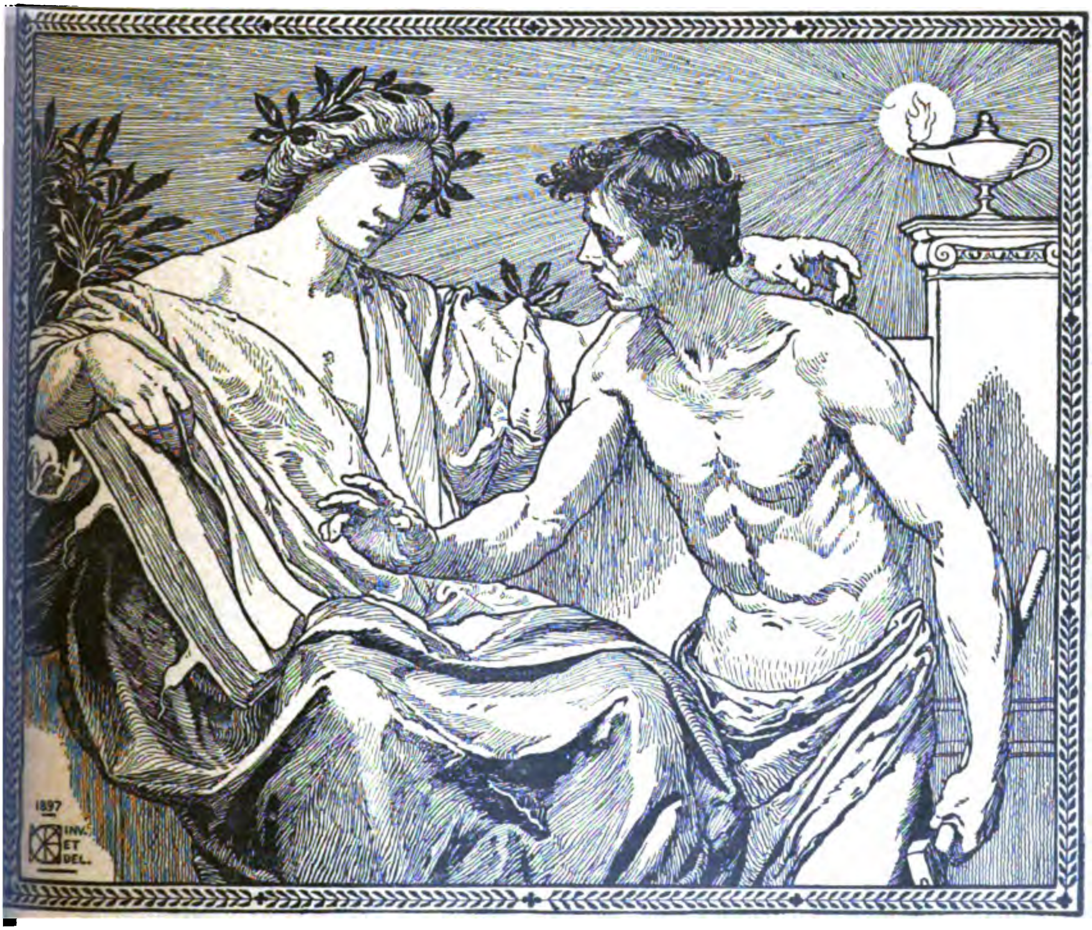

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THE MECHANIC ARTS MAGAZINE.

Vol. IV. AUGUST, 1899. No. 7.

WHY READ THIS MAGAZINE?

THE PRACTICAL USEFULNESS OF AN ENLARGED INTELLIGENCE—THE DEVELOPMENT OF NATURAL GIFTS BY THE ACCUMULATION OF SOUND KNOWLEDGE.

WHY should I read a magazine like this? What is the use of understanding the principles of mechanics? Why should I bother my head about Newton's discoveries, and the law of gravitation? I am not a machine designer, neither am I trying to invent a perpetual-motion machine. Why should I know just why a ball bearing is better in some places than a plain one? I can see that it is; why, then, should I worry about the principles? What do I care about lead pencils, how they are made or how they used to be made? I am not a draftsman. What can there be about the art of rope splicing or the firing and directing of a torpedo that can possibly be interesting or of any practical value to an ordinary landsman like me? What good will it do me to know how steel is tested? I do not use it in my business.

Why, then, should I read THE MECHANIC ARTS MAGAZINE?

Because it will make you more intelligent; because your intelligence, with the power that it gives you of perceiving the laws by which matter in its various forms is controlled, is one of the faculties that separate you from the lower animal creation; because you owe it to yourself to develop your natural gifts; because it is unworthy of a human being to degenerate into a mere machine, performing his part of the world's work automatically, and using the product of other men's brains without taking the trouble to understand the how and why of the results produced by ingenuity and skill.

Learning, says the proverb, is light to carry about. Knowledge of the principles applied in the construction of the common necessaries of every-day life enlarges the mind, quickens the imagination, awakens the perceptions, and opens the way to new interests which are practically unlimited.

Or consider the matter from the standpoint of usefulness. Every fresh piece of information that you possess about useful things adds something to the capital with which you are to make your way in life. Capital does not consist of dollars and cents alone, but includes your health, your brain, your clever fingers, your ready tongue, your kindly, generous heart, which prompts you to help another over a hard place. Every newly acquired fact can and should strengthen your equipment in some one or other of these departments; and the applications of your knowledge of facts are only limited by your opportunities, and your own readiness to grasp them. No one knows as well as a mechanic or a business man how unexpectedly opportunities arise.

But the knowledge must be real and sound; not a vague memory of once having heard of this discovery or of that invention, or of having read something wonderful in a newspaper. It is this sound knowledge that THE MECHANIC ARTS MAGAZINE endeavors to impart, with regard to the simple facts and the common apparatus of every-day life.

Do not say "I have no *time* to read of such things" or "I cannot afford to subscribe for a magazine." You read and pay for the newspaper every day; yet stay: do you *read* it? or does your eye merely follow column after column of worthless details to be forgotten as they are read? You will not deny that you do forget them; nay, you will even admit that you do not wish to remember them. And a word in your ear, my friend: Such reading does you a damage; it tends to

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convert your head into a sieve; it weakens your memory, and fixes on you the bad habit of letting your eye follow the words on the printed page without ever using your mind on the matter therein contained. The day may come when this habit will be a curse to you, for it will hamper you and hinder you when you really want to study and reflect.

And what does your newspaper cost you? Scarcely *less* than 3 cents a day, and that is at the rate of about $11.00 a year; yet at the end of the year you have practically nothing to show for it; you have not only forgotten 99 per cent. of what you have read during the year, but you have thrown the papers away; not even kept that splendidly illustrated Sunday edition (in colors) that contained the graphic account of the aerial gun carriage, and the floating hotel in the middle of the Atlantic, and the electromagnetic thought-reading machine; even *that* was forgotten and thrown away or used for packing dishes in when you moved house last April. And you know just about as much as you did a year ago.

During the year the time you have spent reading the paper amounts in all to several weeks of working days of eight hours a day and it has cost you in cash about $11.00; yet you have nothing to show for it; all you can say is that the earth has made one more "lap," and here we are again at the same old stand, having lived and worked, walked and talked, and done everything else for another year, are just about as much in debt, and I wonder where we'll all be this time next year.

Yet there are a great many things that are worth knowing—just about as many, in fact, as there were this time last year; and if you go along in the same old way, there'll be just about as many this time next year.

Now, why not do a little bit of real reading? It isn't such very hard work, and it will repay you many times over. It may not have any material and immediate effect on your exchequer—that all depends on how you play your cards—but it will strengthen your hand, and perhaps supply you with cards that you never possessed before.

Don't look on reading a magazine like this as "studying." It is not meant to be that, but a useful recreation, and one that you will not tire of. You won't have to worry over mathematical problems or anything of that sort; no doubt you have problems enough in your business; but a number of interesting things will be told, and many other things that you have never understood, though often wondered about, will be explained.

A few weeks ago a gentleman (a surgeon from a New York hospital), while in the office of this magazine, saw in preparation the article on lead pencils that appears in another part of this number. Said he, "So *that's* the way lead pencils are made! How exceedingly interesting! I've often wondered how pencils are made." Then he sat down and read the article through, in the rough, and then and there subscribed for the magazine. "If you publish articles of that kind," he said, "I don't intend to miss any more of them."

Now, what earthly *use* can it be to that surgeon to know how lead pencils are made?

Suppose we answer that question in true Yankee fashion by asking another: What use is ordinary knowledge, anyhow? One can understand why *special* knowledge is of value; no need to ask a surgeon why he is interested in knowing how to amputate a leg; or a builder why he learned how to lay brick; or an engineer what use it is to him to know how to read an indicator card. Such knowledge will buy bread and butter; it has a positive market value; no need to ask any questions about it. But the *other* kind of knowledge?

Here the writer will ask indulgence while he relates a little personal experience. A few years ago I was living on the outskirts of a city, in a house that adjoined a vacant lot. One fine morning building operations were begun on that lot, and in due time the foundations were completed, then the framework went up, and finally the carpenters got to work on the interior. It happened that the bay window of my sitting room faced the new house, so that with the windows open I could hear the carpenters talking, and during the noon hour, when sawing, planing, and hammering ceased for the time, I could hear pretty nearly all that was said. I soon discovered that there was one man who did more talking than all the rest put together, and at first I made up my mind that he was a nuisance—that is, to the other men. One day, curiosity got the better of me and raising the window I listened and watched. The talkative man was seated comfortably on top of a big packing case, with his back against a board and his legs stretched out horizontally, and he was delivering a kind of "lecture" on the United States Patent Office. What he said was to the point and free from all exaggeration, but

he said so many sarcastic things about inventors in general and the Patent Office in particular, that I concluded he must have had "experience" as an inventor and been bitten pretty hard some time or other. The next day I listened again, and to my surprise the same man was talking about flowers—the wild flowers of the woods—and it was a treat to hear him, he was so much in earnest, and so thoroughly familiar with the subject. I now began to suspect that I was listening to a remarkably intelligent and well-informed man, and the next day settled the matter beyond all possible doubt. He began by talking about the pendulum; then somehow or other he got around to bicycles, and one of the men asked him a question: "Say, Charlie (they called him Charlie), can you tell me why it's so much easier for a man to ride a mile on a bicycle than to *walk* a mile? That's something I've never been able to understand." "Why, certainly," said Charlie. "It's just this way: When you're riding a wheel, your body moves in practically a straight line, and all you've got to do is to overcome the resistance of the air and the friction in the wheel; but when you're walking, you have to lift yourself up and put yourself down again every step you take, and if you weigh a couple of hundred, like I do, why, you're doing a "putty consid'able" amount of work. That's about all there is to it." The next day he talked about carpenters' tools, different makes and qualities, and gave some good practical pointers. At another time I heard him explaining how wines and liquors are adulterated. Now, this man was head and shoulders above any others in that crew, and, of course, he was the "boss." It wasn't long before I got to know him, and I found that, whatever his topic, he knew what he was talking about; he did not talk in generalities, but of things that he really understood. He was interesting not only to listen to, but to talk to; and why? Because he was intelligent and well informed; he really knew something—something outside of his business. There was no mathematics in what he said, no abstruse or learned reasoning that was difficult to follow; but he was chuck full of information, and just "told things" in a simple, direct way, so that others could understand. On entering his house the first thing one noticed was the number of books scattered around—not novels, but books—and there was a microscope on top of the bookcase, all ready for use; and hanging on the wall there was a violin, and he played it well, too—must have practiced hours, days, weeks, to "get there." He wasn't wealthy in cash—just comfortably off—but he was a Crœsus in resources for enjoyment, and these riches he shared with any one who cared to share them with him.

He had acquired a knowledge of these things just as the New York surgeon learned how lead pencils are made, and for the same reason—because he had a clear, alert, intelligent mind, and all fresh knowledge was a source of pleasure to him. May it not possibly be a source of pleasure to you?

That the general public is ever willing to listen when interesting things are told, there is no doubt; otherwise, why should the newspapers watch so closely and so jealously for every new invention and discovery that can possibly be made the subject of a sensational article? But newspapers are made to *sell*, and though they contain much news from day to day that it is your duty as a citizen to read, it is not right that they should be your one and only source of *scientific* knowledge, however plausibly and attractively such knowledge is presented. It may have *seemed* very interesting to read about that aerial gun carriage, and about that floating hotel and the electro-magnetic thought-reading machine, but it was a most unprofitable way of spending your time, whether it was a Sunday or a weekday, because you knew perfectly well, if you stopped to think about it at all, that every word of it was impossible nonsense.

Then, why waste your time reading such stuff? Why not, instead, read about things that really *are?* Every detail of your surroundings is interesting if you only knew something about it. You possibly flatter yourself that you live in an enlightened age. 'Tis quite true that you do; a great deal is known today about the sun and the moon and the stars that was not known a thousand years ago; a thousand years ago they didn't make as much use of electricity as they do now; no one had ever dreamed of dynamite guns and torpedoes; gunpowder had not been invented; bicycles were unknown, so were automobiles and even pneumatic-tired buggies; and neither telephones, nor phonographs, nor kinetoscopes, nor amateur photography had appeared on the face of the earth. But how much do *you* know about these things? It's all very well to live in an enlightened age, but don't you think it would be as well if you understood some of the things that go to make the age so very enlightened?

DESIGNING MACHINERY.

D. Petri-Palmedo.

THE BEGINNING OF THE CAREER—CHANGING AN EXISTING DESIGN—A CASE IN POINT.

PART II.

AFTER bidding the machinist draftsman to first of all sit down and study, it might, perhaps, be now in order to map out for him a regular course in machine designing, beginning with an enumeration of the theoretical studies to be pursued, and winding up with discussions of various types of machinery, somewhat on the basis of a college catalogue. The writer could thus acquit himself of the task gracefully and with ease, but it is probable that the stately array of studies alone, to say nothing of the learned discussions following them, would fill with awe and despair the heart of the man who, though ambitious to become a competent designer, has still to work for a living. Now, as a matter of fact, the draftsman entering the field of machine design has but to master the very elements of mathematics and mechanics before he already feels the enormous help this newly acquired knowledge is to him; and he will find himself almost daily in position to usefully apply it. It is this that affords the greatest encouragement to the man who has to advance himself by his own efforts. As time goes on he will have no difficulty, in this age of books, in selecting his studies, but in starting out it is essential for him to take up elementary geometry, algebra, and mechanics (notably that branch of mechanics which comes under the head of "strength of materials").

In the beginning of his career the designer will have little use for the higher branches of science, because he will not be called on right off to design a steam engine or a printing press or any other kind of complete machine, all by himself; he could not do it if he were, even though he had at his finger ends all the necessary theoretical knowledge such as the college affords, without that particular training which long and close association with detail work alone can give.

Let us accompany the machine designer from the time he enters the field as draftsman pure and simple. In doing so we must needs choose a hypothetical case, and our choice may naturally be of the type that leads most directly to a successful end.

As previously stated, the tendency with most machine builders is to confine themselves to the manufacture of one special kind of machinery. A great deal of the work in the drafting rooms of such concerns consists in the mere alteration of existing designs to suit special conditions, and it is this kind of work that the young designer is generally first entrusted with. It must not be supposed, however, that it is necessarily *easy* work; on the contrary, it may prove quite as difficult as designing a new machine, and, under some circumstances, even more difficult.

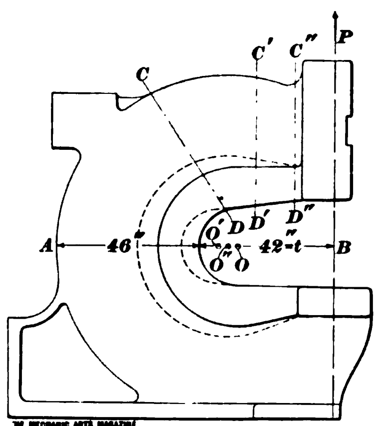


FIG. 1.

We deem it proper, right here, to impress on the young designer the great importance of being systematic about one's work. Any work that is worth doing at all is worth doing well, and all calculations and sketches should be so made that, at later occasions, they can be referred to with certainty. The designer should keep a book for this purpose, and not make his calculations on fly leaves or scraps of paper. A habit of neatness and systematic treatment of even the smallest detail will prove a source of enormous saving in both time and labor. This is particularly true of intricate numerical calculations; no living man, be he ever so excellent an arithmetician, is infallible, and mistakes will creep in now and then. If the figuring has been done in a desultory way on little bits of scrap paper, all jumbled up, it will be difficult, if not impossible, to

trace the mistake, especially if a few days have elapsed in the meantime.

Fig. 1 represents the familiar cast-iron frame of a punching press. The press is designed to punch a 1½-inch hole in a ¾-inch plate, 40 inches from the edge. The throat is therefore made 42 inches deep, to give clearance to work in. Now, a customer wishes to purchase one of these presses, but stipulates that the throat must be 48 inches deep, as shown in dotted lines in Fig. 1. We will assume that the press is some special make and that no larger size has been built; also, that it is doubtful if there will be any further demand for this particular style and size of press. It is decided, then, instead of making a new pattern, to try to so alter the old one that it will satisfactorily serve the purpose for this order. This has to be done with as little expense as possible, of course, and without injury to the old pattern; and it is further required that the finished job shall not look as though it had been patched.

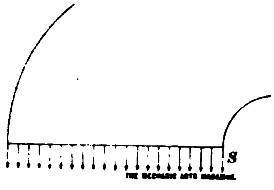


FIG. 2.

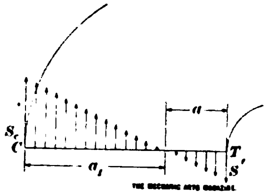


FIG. 3.

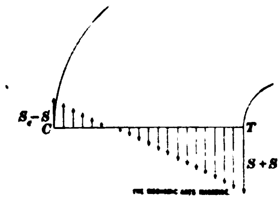


FIG. 4.

In carrying out this order, we first make a sketch of the old frame and shift the center of the circle, marking the bottom of the throat 6 inches from O to O'. This would leave the depth of the frame on line $A\,B$ 40 inches, making the weakening effect of the increased throat depth at once apparent; this will be the more so if we also shift the circle indicating the rib of the jaws an equal distance. To even up, we so plan the rib circle that the depth beyond it will be as nearly as possible uniform all around. So much for outside appearances. The loss of metal at the section $A\,B$ must be compensated for in order to make the new frame as strong as the old one. To get at the strength of the frame at this section we first recognize that here is a case of eccentric stress. The pressure of the punch on the plate tends to force the jaws apart, which tendency is resisted by the various parts of the frame. The effect on the section $A\,B$ is twofold. The force P not only tries to pull the upper half of the frame vertically upward, thus producing a tension all over the section, as indicated in Fig. 2, but also tries to turn it round an axis passing through the center of gravity of the section, thus producing tension to the right of that axis and compression to the left, as indicated in Fig. 3. Combining these stresses, we can represent them as in Fig. 4. The magnitude of the stress per square inch due to the direct pull, Fig. 2, is expressed by the formula $S = \frac{P}{A}$, in which A is the area of the section $A\,B$. The stress due to the bending action, Fig. 3, is expressed for the tension at T by the formula

$$S' = \frac{P(t+a)a}{I},$$

and for the compression at C by the formula

$$S_c = \frac{P(t+a)\,(h_0 - a)}{I},$$

in which $t =$ depth of the throat;
a and $(h_0 - a) =$ distances from the center of gravity to the outermost points of the section;
$I =$ moment of inertia of the section.

Combined, the stresses for the tension are expressed by the equation:

$$T = S + S' = \frac{P}{A} + \frac{P(t+a)a}{I},$$

and for the compression by the equation

$$C = S - S_c = \frac{P}{A} - \frac{P(t+a)\,(h_0 - a)}{I}.$$

The problem is now to so arrange the material in our section that C and T shall not exceed a certain number of pounds per square inch. In order to make use of the above formulas, we must first ascertain the values of I and a. For the purpose, we must first lay out a section by guess, calculate its moment of inertia, and insert same in the stress formulas to see if the result is satisfactory. If this is not the case, that is, if T or C comes out too large or too small, the whole operation must be repeated by laying out another guess section.

The calculation of I is a troublesome job, requiring time and patience. Every means possible, therefore, should be used to lessen this work. Among these means there is, first of all, the establishment of a formula for the section, if this is practicable. For

most simple figures such formulas are found in every engineering pocketbook, but for unusual forms they must be expressly established. In many cases such formulas become too cumbersome to be of any practical value, and numerical calculation is then resorted to at once. When the section can be divided into a number of rectangles or triangles having a common basis, the following formulas will be found very useful:

Rectangles:

$$I = \frac{A_0 h_0^2 + A_1 h_1^2 + \ldots A_n h_n^2}{12} + \frac{A^0 A_1}{A_0 + A_1} e_1^2 + \frac{(A_0 + A_1)A_2}{A_0 + A_1 + A_2} e_2^2 + \ldots \frac{(A_0 + A_1 + \ldots A_{n-1})A_n}{A_0 + A_1 + \ldots A_n} e_n^2,$$

$$e_n = a_{n-1} - \frac{h_n}{2},$$

$$a_n = \frac{A_0 h_0 + A_1 h_1 + \ldots A_n h_n}{2(A_0 + A_1 + A_2 + \ldots A_n)}.$$

Triangles:

$$I' = \frac{A_0' h_0'^2 + A_1' h_1'^2 + \ldots A_n' h_n'^2}{18} + \frac{A_0' A_1'}{A_0' + A_1'} e_1'^2 + \frac{(A_0' + A_1')A_2'}{A_0' + A_1' + A_2'} e_2'^2 + \ldots \frac{(A_0' + A_1' + \ldots A_{n-1}')A_n'}{A_0' + A_1' + \ldots A_n'} e_n'^2,$$

$$e_n' = a_{n-1}' \frac{h_n'}{3},$$

$$a_n' = \frac{A_n' h_n' + A_1' h_1' + \ldots A_n' h_n'}{3(A_n' + A_1' + A_2' + \ldots A_n')}.$$

The formulas for rectangles and triangles can be used in combination by first finding I, e, and a for one set, then for the other, and then combining the results in the following formulas:

$$I_{total} = I + I' + \frac{A A'}{(A + A')} E^2.$$

$$E = a_n - a_n'.$$

$$a_{total} = \frac{A a_n + A' a_n'}{A + A'}.$$

In which A and A' are total areas.

When a rectangle or triangle is to be subtracted from a section, it must be introduced into the formulas with the negative sign.

We shall now proceed to apply these formulas to our case. Fig. 5 is a section of the old frame at $A B$, the dotted lines indicating the new outlines after shifting the throat and the jaw ribs. We will first see what the stresses T and C amount to if we make no further changes. For this purpose we divide up the new sections as indicated in Fig. 5 and make in our book the schedule given in the next column.

For determining the stresses T and C, we must first know the value of P, which is evidently dependent on the shearing strength of the metal plate to be punched, as well as on the size of the punched hole. It is, however, also dependent on the style of punch used, the speed of the punching operation, and the condition of the punch and die. If the shop makes a specialty of punching presses, there will be in use a certain empirical value determined by experience for the resistance encountered by the punch per square inch of sheared surface. The young designer cannot be expected to know this empirical

NOTE BOOK SCHEDULE.

$b_0 = 20$, $h_0 = 40$	$b_0 h_0 = A_0$	= 800	$A_0 h_0$	= 32,000	$A_0 h_0^2$	= 1,280,000
$-$ { $b_1 = 16$, $h_1 = 38$	$b_1 h_1 = A_1$	= $-$ 608	$A_1 h_1$	= $-$ 23,104	$A_1 h_1^2$	= $-$ 877,952
	$A_0 + A_1$	= 192	$A_0 h_0 + A_1 h_1$	= 8,896	$A_0 h_0^2 + A_1 h_1^2$	= 402,048
$b_2 = 4$, $h_2 = 14$	$b_2 h_2 = A_2$	= 56	$A_2 h_2$	= 784	$A_2 h_2^2$	= 10,976
	$A_0 + A_1 + A_2$	= 248	$A_0 h_0 + A_1 h_1 + A_2 h_2$	= 9,680	$A_0 h_0^2 + A_1 h_1^2 + A_2 h_2^2$	= 413,024
$b_3 = 16$, $h_3 = 8$	$b_3 h_3 = A_3$	= 128	$A_3 h_3$	= 1,024	$A_3 h_3^2$	= 8,192
	$A_0 + A_1 + A_2 + A_3$	= 376	$A_0 h_0 + A_1 h_1 + A_2 h_2 + A_3 h_3$	= 10,704	$A_0 h_0^2 + A_1 h_1^2 + A_2 h_2^2 + A_3 h_3$	= 421,216

$$a_0 = \frac{h_0}{2} = 20.$$

$$a_1 = \frac{A_0 h_0 + A_1 h_1}{2(A_0 + A_1)} = \frac{8,896}{2 \times 192} = 23.167.$$

$$a_2 = \frac{A_0 h_0 + A_1 h_1 + A_2 h_2}{2(A_0 + A_1 \times A_2)} = \frac{9,680}{2 \times 248} = 19.516.$$

$$a_3 = \frac{A_0 h_0 + A_1 h_1 + A_2 h_2 + A_3 h_3}{2(A_0 + A_1 + A_2 + A_3)} = \frac{10,704}{2 \times 376} = 14.23.$$

$$h_0 - a_3 = 40 - 14,234 = 25.77.$$

$$e_1 = a_0 - \frac{h_1}{2} = 20 - 19 = 1.$$

$$e_2 = a_1 - \frac{h_2}{2} = 23.167 - 7 = 16.167 \sim 16.2^*;\ e_2^2 = 262.44.$$

$$e_3 = a_2 - \frac{h_3}{2} = 19.516 - 4 = 15.516 \sim 15.5;\ e_3^2 = 240.25.$$

$$I = \frac{421,216}{12} - \frac{800 \times 608}{192} \times 1 + \frac{192 \times 56}{248} \times 262.44 + \frac{248 \times 128}{376} \times 240.25 = 35,101.83 - 2,533.33 + 11,378.04 + 20,283.25.$$

$$I = 64,219.27 \sim 64,300.$$

value; therefore, he should ask his superior, and should not be afraid to do so. If the head draftsman is a sensible man, he will cheerfully give such information—if he

*The sign $\sim$ is a convenient one to denote approximate results.

possesses it himself. Let us assume that 63,000 pounds per square inch is considered a safe value for the resistance offered by an iron plate. We then have

$$P = 63{,}000 \times \pi \times 1\tfrac{1}{2}'' \times \tfrac{3}{4}'' = 222{,}660.9 \backsim \mathit{230{,}000}\ \text{lb.}$$

$$\frac{P}{A} = \frac{230{,}000}{376} = 611.7.$$

$$\frac{P}{I} = \frac{230{,}000}{64{,}300} = 3.57 \backsim 3.6.$$

$$\frac{P}{I}(t + a_3) = 3.6 \times (48 + 14.23)$$

$$= 3.6 \times 62.23 \backsim \mathit{224}$$

$$\frac{P}{I}(t + a_3)\,a_3 = 224 \times 14.23 = 3{,}177.52\ \text{lb.}$$

$$\frac{P}{I}(t+a_3)(h_0-a_3) = 224 \times 25.77 = 5{,}772.48\ \text{lb.}$$

$$T = 611.7 + 3{,}177.52 = 3{,}789.22 \backsim \mathit{3{,}800}\ \text{lb.}$$

$$C = 611.7 - 5{,}772.48 = -\,5{,}160.78 \backsim -\mathit{5{,}200}\ \text{lb.}$$

For cast iron subjected to quickly varying loads, as in our case, the permissible tensile stress should not exceed 2,850 pounds, while the compressive stress may safely be three times as great, or 8,550 pounds. For this reason the metal on the original frame was crowded toward the tension side, and in making up the altered section we must do the same. By far the greater portions of the stresses T and C are due to the bending action of the load, and they are proportional to a and $(h_0 - a)$. Now, as C may be three times as great as T, our endeavor should be to so place our additional stock in the frame section that a will be as nearly one fourth of h_0 as practicable under the existing circumstances. As we are not to injure the old pattern nor to incur great expense in its alteration, there remain only two ways to put on more metal: by reducing the core, and by patching on at the sides of the pattern—in both cases crowding the metal toward the throat. It will at once seem natural to increase the depth of the jaw ribs, inasmuch as patch pieces must be made anyhow. Besides, this will be the most effective disposition of the metal, as it will tend more to throw the gravity axis of the section toward the throat or tension side than reducing the core would. We will therefore leave the core as it is (thereby, at the same time, saving the expense of altering the core box), and add to the jaw ribs. It is further evident that adding a triangular piece to the ribs will be more effective than a rectangular one. For this we have, when $b' = 16$, $h' = 14$,

$$A' = \frac{b'h'}{2} = 112,\quad I' = \frac{A'h'^2}{18} = 1{,}219.56,$$

$$a' = \frac{h'}{3} = 4.67,$$

and for the total section

$$a_{total} = a_4 = \frac{A\,a_3 + A'\,a'}{A + A'} =$$

$$\frac{376 \times 14.23 + 112 \times 4.67}{488} = 12.03 \backsim \mathit{12}.$$

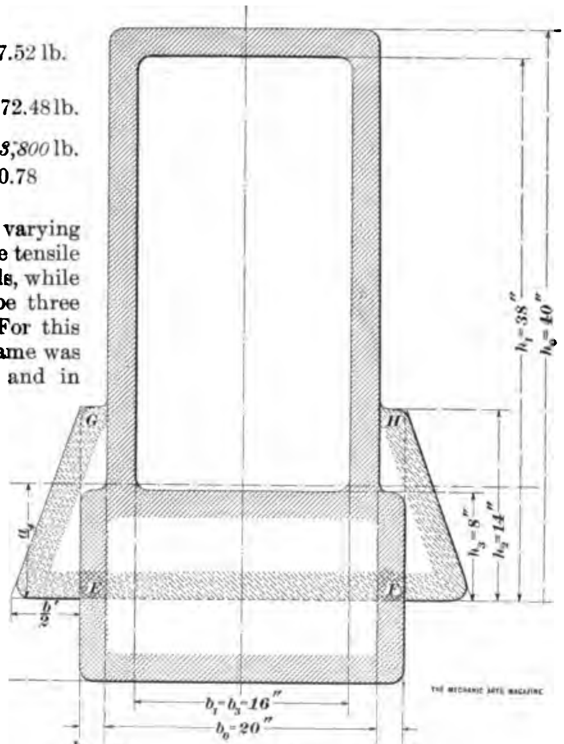


FIG. 5.

$$E = a_3 - a' = 14.23 - 4.67 = 9.56;$$

$$E^2 = 91.39.$$

$$I_{total} = 64219.27 + 1219.56 + \frac{376 \times 112}{488}\,91.39$$

$$= 73{,}325.32 \backsim \mathit{73{,}300}.$$

$$\frac{P}{A} = \frac{230{,}000}{488} = 471.29.$$

$$\frac{P}{I} = \frac{230{,}000}{73{,}300} = 3.14.$$

$$\frac{P}{I}(t + a_4) = 3.14 \times (48 + 12) = 188.4.$$

$$\frac{P}{I}(t + a_4)\,a_4 = 2{,}260.8.$$

$$\frac{P}{I}(t + a_4)(h_0 - a_4) = 188.4 \times 28 = 5{,}275.2.$$

$$T = 2{,}732.09 \backsim 2{,}750 \text{ lb.}$$

$$C = 4{,}803.91 \backsim 4{,}800 \text{ lb.}$$

These results are quite satisfactory. The fact that the tension is even below the permissible limit allows rounding the corners. The other sections of the frame C, $C'D'$, $C''D''$, and so forth, are the less affected by the change of throat depth the nearer they are to the head. The triangular increase of thickness of the jaw ribs has therefore not to extend all round, but should gradually decrease into the flat original shape towards the head.

The practical execution of the alteration of the frame is simple enough, and consists in making a core box for a core of crescent shape to be put into the mold, thus giving the increased throat depth. For the pattern, detachable core prints must be made, and detachable patch pieces for the ribs.

The foregoing example illustrates a certain kind of work that young designers are likely to be called upon to do. That it requires not only common sense, but also familiarity with the theories of the mechanics of material and dexterity in the handling of figures, is evident. It is not always, however, that a case of alteration reduces itself to a simple question of strength, and in many cases other considerations are the determining ones. For instance, if for a machine tool a certain attachment is to be made that will enable the machine to do a certain job for which it was not originally intended, the new piece or mechanism must be so schemed that it will conveniently fit into the existing machine, that its attachment shall not destroy any of the qualities of the tool, that it can be easily and cheaply made, that it may be used, if possible, for a variety of similar work, etc. This kind of work, which is known as *toolmaking*, requires a great deal of personal ingenuity as well as knowledge of the wants of the shop. We shall have occasion to speak of this later on.

(*To be Continued.*)

JOURNAL BEARINGS.

Henry G. Palmer.

WHAT BEARINGS IN GENERAL ARE FOR—COMPARISON OF THE PRINCIPAL TYPES—WHY ROLLER AND BALL BEARINGS ARE NOT USED MORE THAN THEY ARE IN MACHINERY.

IN THESE days of much bicycle riding, everybody knows what a ball bearing is, and all cyclists are more or less familiar with its construction. They know that, as compared with the "old timer," the bicycle of 1899 is wonderfully easy to push, and some of them, realizing that the improvement is mostly due to the adoption of the ball bearing, have been known to ask why this particular kind of bearing is not used more than it is in machinery; if it is good for a bicycle, why not for a locomotive engine? Now, this proves that there are misunderstandings about the subject; so, as THE MECHANIC ARTS MAGAZINE is supposed to set people right, it is only proper that something be said about bearings.

The subject is not a very big one (except in detail, and we shall not enter into detail here), so it will pay to begin at the beginning and get a clear idea, first of all, what a bearing is for.

In practically all machinery, some force having definite direction in a straight line is made to act on a combination of links and levers in such a manner as to cause the motion in a straight line to be converted into motion of some other kind. For example, in the steam engine, the pressure of the steam in the cylinder causes the piston to move in a straight line; the piston is provided with a rigidly attached piston rod, the end of which is connected to one end of a link called a *connecting-rod;* this rod, at its other end, is attached to the end of a lever called a *crank*, the other end of which is fixed to a cylindrical shaft. As every one knows, the straight-line motion of the piston, acting through this combination of link and lever, causes the shaft to rotate upon its own center. The rotary motion thus obtained is then transmitted by means of shafting, pulleys, belting, etc. to machines. In the machines the motion is either retained as circular or again changed into some other kind, according to the nature of the work to be done; for instance, in a lathe, part of it is retained as rotary motion, causing the

piece to be operated on to rotate, and part is converted back into straight-line motion, causing the saddle to slide along the bed; in a planer, it is all reconverted into straight-line motion, causing the platen to travel backward and forward, and the cutting tool to be fed in a straight line across the work; in a buzz-saw, the only change is one of velocity; in a locomotive, it is all changed back to approximately straight-line motion by the contact of the driving wheels with the rails.

Now, it is very evident that a piston cannot slide unless it has something to slide on, and that a shaft cannot rotate unless it has something to rotate on; everything, whether moving or at a standstill, has to rest on something—has to be *supported;* it is equally evident that all moving parts have also to be *guided.* In machinery, a supporting guide—that is, a support that guides a moving part—is called a *bearing.*

A bearing for a rotating shaft has to do more, then, than simply support the shaft; it must guide it; but in machinery it must do more than this: it must guide it *positively*—with *precision*—yet at the same time leave it free to rotate. A perfect bearing, then, would be one that, while supporting a shaft, guides it positively without offering any resistance to rotation; such a bearing is impossible, every bearing offering more or less frictional resistance to the rotation of the shaft that it supports.

There are, in the main, two ways in which a rotating shaft can be supported — lengthways and on end; and thus there are two main kinds of rotation bearings—*journal* and *end;* of each of these there are several kinds and an endless number of possible designs. The principal journal bearings now in common use are the *plain cylindrical,* the *wheel,* the *roller,* the *ball,* and the *ball-and-roller;* these are represented diagrammatically in Figs. 1 to 5.

FIG. 1.

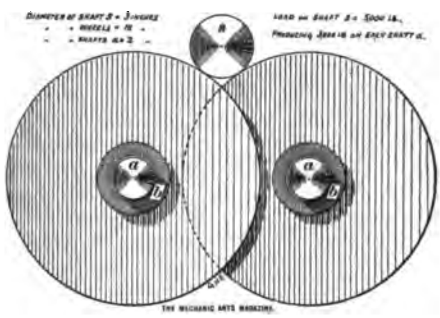


FIG. 2.

FIG. 3.

FIG. 4.

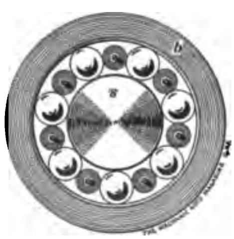


FIG. 5.

In the plain cylindrical bearing of Fig. 1, the resistance to rotation is due to direct sliding friction between the surface of the shaft s and the surface of the bearing b; in the wheel bearing of Fig. 2 it is due to sliding friction between the smaller shafts a, a and the cylindrical bearings b, b; (it is customary, when considering the frictional resistance of the wheel bearing, to neglect the infinitesimal amount of resistance due to the rolling friction between the shaft s and the wheels.)

In order to compare these two bearings, let us take the case of a shaft 3 inches in diameter, rotating under a load of 5,000 pounds. Assuming the coefficient of sliding friction to be .08, it is evident that, during one revolution of the shaft in Fig. 1, the amount of work done in overcoming frictional resistance is equal to

$$5{,}000 \times .08 \times 3 \times 3.1416$$
$$= 3{,}770 \text{ in.-lb.}$$

During one revolution of the shaft in Fig. 2, it is plain that each of the 12-inch wheels makes one-fourth of a revolution, so that, with the shaft diameters and the pressures of 3,000 pounds due to the load of 5,000 pounds, the work done in overcoming frictional resistances during one revolution of shaft s is equal to

$$\frac{2 \times 3{,}000 \times .08 \times 2 \times 3.1416}{4}$$
$$= 754 \text{ in.-lb.}$$

This is just one-fifth of what it is with the plain cylindrical bearing.

So far as resistance to rotation is concerned, then, the wheel bearing has a decided advantage over the cylindrical; yet it is very little used in machinery, for the very good reason that although it supports the shaft, it is not a positive guide—does not hold it securely in position—and is only at all suitable where

the load is always downwards, as, for instance, for supporting a grindstone that is driven by foot- or hand-power, or as an auxiliary support for a long shaft, such as the traversing shaft of an overhead hand traveling crane.

In the bearing shown in Fig. 3, small rollers are introduced between the shaft and the bearing. Everybody is more or less familiar with the principle involved, having seen rollers similarly used for facilitating the moving of heavy loads along the highway, or when moving a heavy safe from one room to another; and every one knows that the rollers have a tendency to crush into what they are rolling on. Theoretically, a roller between a shaft and a bearing is in contact along two lines only; but, actually, the roller is slightly flattened along these lines, and to a slight extent it sinks into the shaft and bearing; Fig. 6 makes clear what this means. Constant rolling under these conditions causes wear, though the amount can be and is made very small by lining the bearing with a hardened-steel bushing. Again, there are mechanical difficulties connected with this kind of bearing; the rollers have to be kept in line with the axis of the shaft, and, therefore, have either themselves to be supported on small end bearings in a carrier ring at each end or else separated and held in line by means of a cage, as shown in Fig. 3. Such a bearing is suitable, then, only where a little play in every direction does no harm, because, owing to the small areas in contact, wear is rapid, and then it does not maintain the position of the shaft with precision—is not a positive guide.

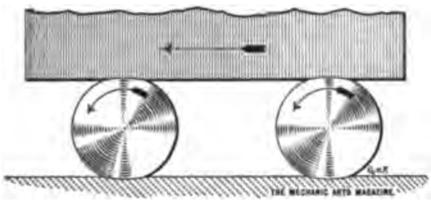


FIG. 6.

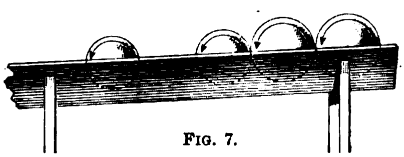


FIG. 7.

And now we come to the ball bearing. In this, instead of rollers, perfect spheres of hardened steel are introduced between the shaft and the bearing, suitable grooves being provided for them to roll in, as shown in Fig. 8. The advantage of the ball bearing over the roller is that, whereas the rollers have to be held in line with the axis of the shaft, the balls can be left free to turn over in any direction without affecting either the position of the shaft or the resistance to rotation, so that they need not be carried in a cage or supported in any other way than by the grooves in which they roll. Such a bearing, however, is far from being a positive guide, for the bearing areas are but slightly flattened *points*, and wear is rapid; here, again, however, the amount of wear is reduced to a minimum by making the balls and the grooved surfaces of hardened steel. There is another thing that must be noticed about the ball bearing: Though the rotation of the shaft causes all the balls to rotate around the shaft in the same direction, the rear surface of every ball moves in an opposite direction to the front surface of the ball behind it; and thus there is sliding friction between every ball and the two that it is between. Again, if one of the balls is slightly larger than the rest, either when the bearing is new or after being in use for some time, and due then to uneven wear, this friction between the balls may be quite severe, because the larger ball will want to travel around the bearing faster than the rest, and will therefore crowd the others together.

FIG. 8.

To help the reader to fully appreciate the significance of this friction between the balls, we show in Fig. 7 part of a bowling-alley ballway, down which the balls are returned to the bowlers. It is easy enough for one of these balls to roll down hill by itself, but things go much less merrily when several of the balls come in contact. Of the three shown touching in Fig. 7 it will be seen that the middle ball has two others to rub and grind against, the result being that these three soon come to a standstill, while the loose ball shoots ahead and races home.

A practical way to prevent this grinding action is to place a small roller, on bearings, between every two adjacent balls, and this has been done lately by a Mr. Burwell, of Cleveland bicycle fame, the result being the ball-and-roller bearing shown diagrammatically in Fig. 5; the actual construction of Mr. Burwell's bearing is shown in Fig. 9.

In this, the surface motion of the balls and rollers is continuous, and practically the only sliding friction is that due to the very slow and slight rubbing of the tiny pins upon which the rollers are carried. So far as it is mechanically possible to make it, then, this bearing is frictionless. But here, again, it is not a positive guide.

FIG. 9.

It is interesting to note how the three forms of bearings — cylindrical, roller, and ball—compare as regards strength and durability. Experiments made in France some years ago show that, taking the crushing strength of a 1-inch cube as 100 (not 100 *pounds*, but simply 100), the strength of a cylinder 1 inch in diameter and 1 inch long, while resting on its side, as at *b* in Fig. 10, is 32, and that of a 1-inch sphere (*c*, Fig. 10) is 26. It is evident, therefore, that the plain cylindrical bearing (analogous in strength to the cube) has a great advantage as regards strength; and, as regards durability, it has a still greater advantage, for in it the surfaces in contact may be made as large as desired and the pressure can be evenly distributed, whereas with the roller and the ball bearing the contact surfaces are little more than lines and points respectively, the pressure being therefore concentrated, and the resulting wear rapid where the pressures are heavy.

From the foregoing the reader must not understand that roller and ball bearings are no use mechanically; on the contrary, they

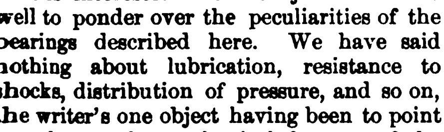


FIG. 10.

have an ever-growing field of usefulness; but if he is interested in the subject he will do well to ponder over the peculiarities of the bearings described here. We have said nothing about lubrication, resistance to shocks, distribution of pressure, and so on, the writer's one object having been to point out the purely mechanical features of the most common types. Economy of power is of as much importance in a locomotive as in a bicycle, but in the former, absolute security from all possible chances of breakdown is of paramount importance, and even if other things did not stand in the way, the tremendous stresses and strains on the parts of the locomotive make it unsafe to use any but plain bearings. But the other forms have their fields of usefulness; for instance, the hanger-box roller bearing of Fig. 11 (one of the many forms made by The Ball Bearing Company, of Boston) is in every way suitable for line shafting, reduces friction, and is a valuable power economizer. It will be noticed that in this bearing the rollers are divided into short independent lengths; it has been found that this gives greater freedom. One of the most successful roller bearings is that in which each roller is made of a steel ribbon close coiled, like a helical spring, and thus flexible from end to end; this is made by the Hyatt Roller Bearing Co., of Harrison, N. J. Other forms are suitable for the axles of vehicles, especially of automobiles, and are now being much used, and in a large variety of machines and mechanical

FIG. 11.

appliances, among which may be mentioned textile machinery, elevators, trucks, harvesting machinery, windmills, fans, blowers, cream separators, and rope and paper machinery. In all these, as in the bicycle, the chief object is to reduce frictional resistance; pressures on the bearings are comparatively light and a small amount of play does no harm; that is, there is no call for movements of absolute exactness. But in machine tools, engines, and all machinery of precision, where quality depends on the accuracy with which the parts move, it is absolutely necessary that all rotating shafts be positively guided with as little play as will still admit of free rotation; in other words, the bearing must maintain the position of the shaft, no matter at what speed the shaft is rotating or in what direction heavy forces act upon it; thus, in these machines, the plain cylindrical bearing, or some slight modification of it, such as the conical bearing, is used to the practical exclusion of all other kinds.

IN THE WORKSHOP.

(Continued from the July, 1899, Number.)

H. Rolfe.

THE ENGINEERING TRINITY—SOMETHING DRAWINGS ARE NOT EXPECTED TO TELL—THREE KINDS OF FITS IN ENGINE WORK.

THERE are three classes of men engaged in steam-engineering practice—designers, builders, and runners. Let us call them, for convenience, D, M, and R.

D creates the machine—on paper; M (suggesting machinist) builds it and keeps it in repair afterwards; R attends to it while running. The more of M's knowledge D has, the better. R is not really required to have, and generally hasn't, any of either D's or M's knowledge. In engineering works, where machinists abound, R is not much more than a helper; he gets rather higher wages than the latter, and is rated on the books as "engine-tender"— one who tends, or looks after, an engine. In a big power station the engineer in charge is a man of M's caliber, and a little more besides. He has ordinary engine-tenders under him; also, men who look after the boilers and keep up the steam supply. The locomotive engineer, or runner, is on a higher plane than the man who merely runs or tends a stationary engine. This is more particularly so in this country. In Europe the engine driver (as he is called there) is not expected to have any mechanical skill, it being a generally accepted maxim that he is better without it. Be that as it may, it is agreed over there that a machinist never makes a good driver, there being only one English road so far as we know, that is an exception to this, and on that road they favor the mechanic's applying for a driver's job. The layman might think that a man who could design, build, and keep a locomotive in repair could *run* it to the best advantage. Such, however, is not the general opinion, based largely on experience.

In marine work the engineer is on a still higher plane than the loco' runner. He is both M and R and often D too, more or less. At least this is so in British ships, for he must have served at least three years as machinist in marine shops, and one year in the engine room at sea, before getting the lowest grade of certificate. He has under him stokers to keep the steam up, and greasers to attend to the engines in the way of oiling, packing glands, etc. Here there is very little opening or shutting of the throttle or reversing to do—which in some people's minds constitutes engine driving; as a matter of fact, boats often run a couple of weeks without the throttle being closed. The marine engineer, that is the marine engine runner, *is* an engineer, in a much truer sense of the word than one who merely watches the wheels go around.

Now, as just remarked, D may not know much of M's end of the business; generally he doesn't, and M perhaps knows nothing at all of D's. To illustrate: just examine a set of engine drawings, say, for a locomotive. You will find:

1. The holes for the cylinder bolts, hornblock bolts, stretcher bolts, and, in fact, frame bolts generally, marked, let us say, 1″ in diameter. Turning to the bolt drawing, those for the above holes will be also marked 1″ in diameter.

2. The driving box may be marked 11″ wide where it goes in between the pedestals, and if the latter were one casting, forming the horn block of European practice, it would also be marked 11″. Where shoes and wedges are used, the dimensioning is virtually the same.

3. The crosshead wings are marked, say, 3½″ deep, and a reference to other drawings shows the guide blocks (for cylinder and guide yoke) to be 3½″ also. Again, the main crankpin is marked 6″ in diameter, and the main-rod drawing calls for a bore of 6″ also; likewise, the rocker-pin may be marked 1¾″ in diameter, and the rocker-arm the same.

Now, if the drawings were faithfully followed out, and all parts put up exactly to dimensions—that is, to gauge size—the fit would be too slack in some places and too tight in others. In fact, a different fit is called for in every one of the above three cases. This, however, unless we except case (1), does not trouble the designer; it is here that the machinist's special knowledge comes into play. It is his business to know the kind of fit demanded in each case. Personally, we have always, under head (1), specified a "driving fit" where holes are to be rose-bitted in place and turned bolts

driven in. Where shop practice permitted, a "reamed driving fit" was called for, which is better still. Something more than a really *good* fit being required in such instances as case (1), the drawing should be duly noted; otherwise, the machinist might, in some foremen's estimation, have a hole to crawl out of. In (2) and (3), however, we never specify anything as to the fit or nature of the bearing. The erector can only do the job one way—the right way—that is, if he knows his business. If he gets (2) too slack or (3) too tight, it simply shows he is not up to his work. (He cannot, of course, fall back on the drawing, as in case (1), for such information is not supposed to be there given.) In fitting the parts up, there will be more or less filing and scraping to do, according to how close the machine hand has worked; in the case of the rocker and other motion pins, the man who laps them in after hardening has the "last word." Many shops have a "gauger," through whose hands all parts go after leaving the machines, and anything not up to gauge is rejected.

The machinist, then, is concerned with three kinds of fits—driving, sliding, and running, although none, except the first, is specified on the drawing. In some shops dealing with small work (bicycles, motor cars, etc.), where all hand work is reduced to a minimum, the nature of the fit *is* specified. Each part is numbered on the drawing, both assembly and detail drawing, and the various parts noted thus: "To be a driving fit in 6," or "A sliding fit on 11," or "A running fit on 15." The parts are dimensioned to the actual required size, a difference of about three thousandths of an inch, according to the fit, nature of piece, etc., being noted. The machine hand works to this—with micrometers, of course—and the pieces are put together with practically no work on the bench. Returning now to ordinary engine work, something further will be said as to these different fits.

Driving Fit.—As stated, a cylinder bolt hole should be reamed out after drilling, and a bolt of exactly the same taper driven in; this constitutes a driving fit. We may have, further, *light driving fits*, as, for instance, the bolts in main-rod strap. These are often, it is true, made a parallel fit, but that is a very slovenly practice. They should be tapered 1 in 96, that is, $\frac{1}{8}$ inch per foot, and made to drive down lightly—an altogether easier fit, in fact, than cylinder and similar frame bolts. If they wear slack, they can be eased off under the head and then driven home to a fit again; this can't be done with a parallel fit, of course.

Sliding Fit.—An example of this may be seen in the fit of the driving box in its pedestals. By the way, the following question is often asked in technical journals: How much play do you give between the boxes and shoes? the answer varying between $\frac{1}{100}$ and $\frac{1}{32}$ for the total play on the two sides. Now, as a matter of fact, you don't give these things any play at all. If it is a case of repairs, file up the jaws until they are square with the engine, leaving them a shade smaller at the lower end. Take your size from the center of depth and plane the box a shade full; then try up, using a block as fulcrum and a long wooden lever to pry the box up with, pinching her down again by "levering" between box and frame. Having got a good bearing (and here is a case where you want all the bearing you can get, especially when there are no adjustable wedges), you ease the box until it will just fall down of its own weight, with frame stay or thimble bolted up in place. You let it go at that. Now, if the box (with brass and cellar in) will only just drop down of its own weight, you evidently have not got any play—not even $\frac{1}{100}''$;—there is less than no play, in fact, for the boxes will caliper more than the jaws before being forced up; the latter have to spring out to take it. This may be called a *sliding* fit. Another example is the fit of a feather key, such as is used in shafting where gears travel along it or where friction clutches are used. These, however, are made rather an easier fit than the one just mentioned.

Running Fit.—Consider the fit of the crosshead between the guides. Here there *is* play—how much, the erector would not be able to tell you if you asked him. He simply fits up the crosshead so that, when the guides are bolted down at each end, the crosshead, properly oiled, will move freely to and fro by hand. This is tried over, of course, before the piston rod is coupled up, or before the piston head is put on, where the piston rod and crosshead are solid. The amount of play in this case is about $\frac{1}{100}''$, and such a fit is called a *running* fit. Piston rings are also another instance of a running fit; they move freely in their grooves, just sufficiently so as not to bind, a play of about three thousandths of an inch being enough to prevent this.

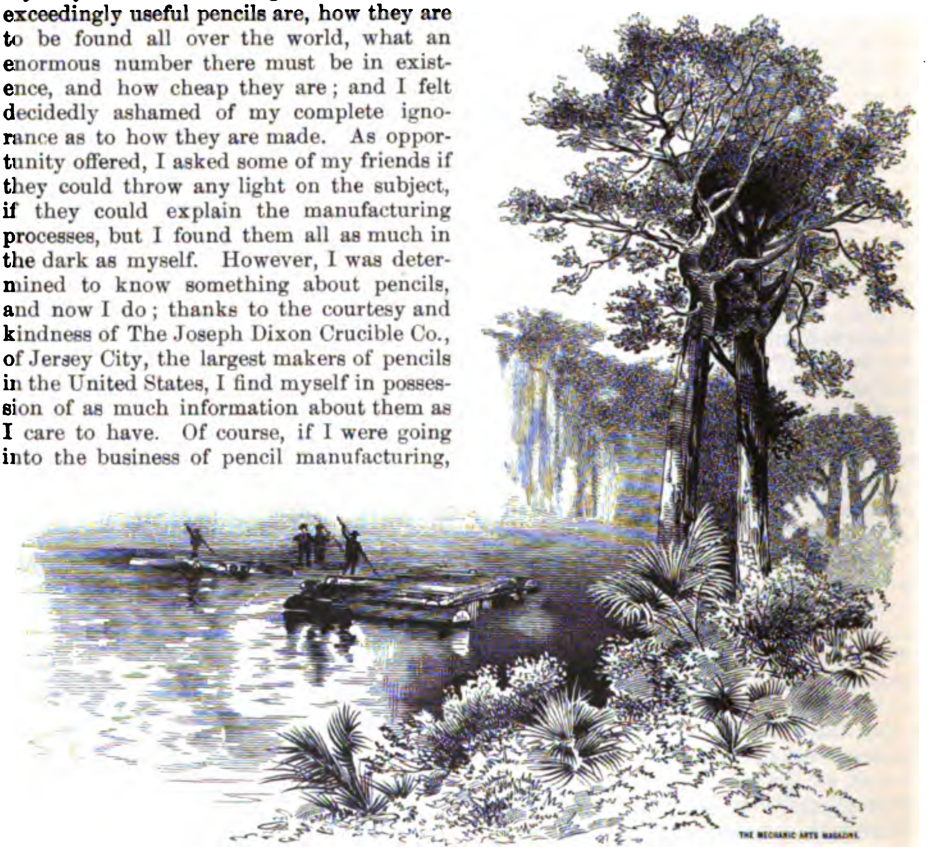
(*To be Continued.*)

LEAD PENCILS.

Walter Bayes.

WHAT WAS LEARNED FROM A VISIT TO THE GREAT AMERICAN PENCIL FACTORY—PREPARATION OF THE LEADS—MAKING THE PENCILS—CHOICE OF GRADE.

A FEW months ago, as I was making a note in my pocketbook, it suddenly occurred to me that the pencil with which I was writing was more or less of a mystery to me. And I began to think how exceedingly useful pencils are, how they are to be found all over the world, what an enormous number there must be in existence, and how cheap they are; and I felt decidedly ashamed of my complete ignorance as to how they are made. As opportunity offered, I asked some of my friends if they could throw any light on the subject, if they could explain the manufacturing processes, but I found them all as much in the dark as myself. However, I was determined to know something about pencils, and now I do; thanks to the courtesy and kindness of The Joseph Dixon Crucible Co., of Jersey City, the largest makers of pencils in the United States, I find myself in possession of as much information about them as I care to have. Of course, if I were going into the business of pencil manufacturing, I would have to know more, but that is out of my line, and probably out of the reader's line too.



RAFTING THE CEDAR LOGS IN FLORIDA.

One of the first things that was told me by the gentleman who showed me around the factory was, "Of course you know there is no *lead* in a lead pencil!" Well, as it happened, I did know this. The fact is, the name *lead pencil* is a misnomer; still, custom has made it correct—rather unfortunately so, I think. The leads are in reality a mixture of *graphite* and *clay*.

Graphite (which word is derived through the French from the Greek word γραφειν, *graphein*, "to write") is a native mineral form of carbon, of black color and brilliant metallic luster; a few pieces are shown to the left in Fig. 1. To the touch it feels smooth, somewhat like soapstone, breaks in a flaky manner under a very light blow, and is so soft that it will leave a trace on paper. Another name for it is *plumbago*, and still another, *black lead*, a misnomer from which, of course, we get the name lead pencil. Graphite is found in the oldest

rock formations, and deposits occur in various parts of the world, the most famous being those at Altai, in Siberia, and at Ticonderoga, N. Y., in this country. The latter deposits are owned and operated by The Joseph Dixon Crucible Co., who, at the outlet of Lake George into Lake Champlain, have a mill ninety feet square and six stories high for the perfecting of the graphite.

Formerly, in the manufacture of pencils, the rough slabs of the mineral graphite were first planed smooth, and then cut into strips by long thin blades set together like the blades of a gang-saw. These strips were then cut crosswise into the length of a pencil, in which form they looked like tiny iron bars. One of these pieces was then inserted in a groove channeled in a piece of wood, another piece of wood being glued to it and the pencil thus completed. This process of using graphite in its native state has long since been superseded by methods that enable the manufacturer not only to cheapen the cost and improve the quality, but also to regulate the product and give it the exact degree of hardness or fineness of grade desired.

The graphite is first reduced to an impalpable powder by grinding; then water is added, and then, in the liquid state, it is passed through mixers. Here it is combined with whatever quantity of clay may be necessary to give it the desired grade. The more clay, the harder the lead, and vice versa.

A word here about the clay. I carried away a few lumps of the dry article, which are shown to the right in Fig. 1. The composition of this clay is the result of years of experimentation, and is a profound secret. In color it is a pale drabbish gray, can easily be cut with a pocket knife, the shaved surface being remarkably smooth and silky, but the chips pulverizing under the lightest touch. When the mixing of the graphite and clay, which is done entirely by machinery, is completed, the mass is run through filter presses in a way to exclude the greater part of the water, and is thus reduced to a doughy consistency. And now, in order to make the mixing still more thorough, this doughy mass is passed through perforated plates, or *dies*, as they are called; this is done under great pressure, and the "leads" issue in tiny rods, or wires, in general appearance not unlike those that are put in the pencils, but instead of being dry and brittle, they are soft and pliable. This treatment of passing through dies is repeated over and over again, through smaller and smaller perforations, until tests show that the mixing is complete; then the material is passed through dies of the exact diameter of the lead that is to go into the pencil; as the pliable leads escape from these final dies, deft fingers take them, straighten them out, and cut them to lengths of about three feet. The leads are now allowed to dry, after which they are cut to the required pencil lengths, packed in crucibles, and burned for several hours, in order to extract every trace of moisture, and to bring the lead to its final condition, ready for inserting in the wooden case. The crucible used in the above process may be described as a rectangular box of such length as to comfortably accommodate the leads; it is fitted with a lid, and, after all has been made snug, is put into a furnace and brought to an extreme heat, and maintained there for a considerable time; then the crucible is lifted out, and, without the lid being touched, is allowed to cool.

FIG. 1.—RAW MATERIALS FROM WHICH THE LEADS ARE MADE.

And now a word or two about cedar wood, the companion product of this pencil graphite. Cedar is a name given to several evergreen trees of the pine family; the wood is remarkable for its durability and fragrant odor. It is superior to any other wood for pencil making, because of the closeness of its grain combined with the peculiar softness which makes it cut almost like cheese. The cedar used in this country is that which grows in Florida, the common red cedar with shreddy bark and aromatic heart-wood. The wood is shipped from Florida in small slabs, a little longer than a pencil, a little wider than four or six pencils placed side by side, and of proper thickness. Notwithstanding the fact that these slabs are carefully assorted where milled out, the first treatment they receive when they reach the factory is careful selection as to grade. Before using, the wood is thoroughly seasoned, and, if it is to be colored for some special grade of pencil, it is also dyed.

FIG. 2.—FOUR STAGES IN THE MANUFACTURE OF A LEAD PENCIL.

If the reader will here take his pencil from his pocket and examine it critically, he will find that the cedar case is made in halves, each half being equally channeled, so that the line of junction comes against the center of the lead. The mechanical processes by which the pencil is made are shown in Fig. 2. At *a* we have the slab of cedar wood as it leaves the mills in Florida; in the first process, this is passed under a rotary cutter, which planes the surface perfectly flat and smooth, and at the same time grooves it to receive six leads, as at *b*; the leads are now laid in the grooves of one of these slabs, and another slab, similarly planed and grooved, is spread with glue and laid upon it; the two thus put together, as shown at *c*, are then placed in a press. When perfectly dry, these are taken out of the press, and passed twice under a grooved rotary cutter, first on one side, producing what is shown at *d*, then on the other, which separates the pencils. The individual pencils are now passed through still other machines, in which they are polished, varnished, and stamped, and put in cases, ready for delivery to the wholesale and the retail trade.

Before leaving the factory, I was presented with the bunch of pencils shown in Fig. 3. Of these no two are alike either in grade or size. There are thick and there are thin pencils, long and short pencils, round pencils, hexagonal, triangular, flat, oval, tapered, and parallel pencils, as well as odd shapes; and there is one of solid graphite, short and thick, called a "lumber pencil," having no other covering than a coat of varnish. I was particularly struck by the great variety of rubber ends; some of these can be seen in the illustration.

Irrespective, however, of the shape, size, color, or finish of a pencil, is the grade or hardness of the lead which it carries. The grades are indicated by the letters that appear on the pencils in connection with the stamp, and which to many are at first sight mysterious. Of the ordinary pencil there are eight grades, the softest of which

is marked S, meaning *soft* (for heavy shading); then, following in order, are SB, *soft black* (for heavy shading); SM, *soft medium* (pocket and office); MB, *medium black* (pocket and mechanical); M, *medium* (memorandum books); MH, *medium hard* (drawing classes); H, *hard* (ledgers and outlines); and VH, *very hard* (finest lines). Of artists' and draftsmen's pencils there are eleven grades, beginning with VVS, *very, very soft*, and ending with VVH, *very, very hard.*

The ability to make a wise choice of grade is an important matter. In this connection, being somewhat of an artist myself, I speak from experience, having had the fact brought home to me on several occasions, sometimes in a rather trying manner, as when pressed to make a sketch of a friend with no more suitable tools than a sheet of smooth paper and a VH pencil. Now, in sketching, the grade of the pencil and the nature of the surface of the paper are matters of the greatest possible importance. To illustrate: In Fig. 4, the sketch on the left was made with a proper grade of pencil, namely SM, on a Whatman's sketching pad, the result being a picture full of snap, effective and satisfactory in every way. The copy of it on the right was made with the same hand and on the same paper, but with a VH pencil, and this was the best that could be done with it.

FIG. 3.

FIG. 4.

To return for a moment to the matter of size and shape: this is of much greater importance than might at first be supposed. Newspaper reporters and all who have to make frequent and prolonged use of the lead pencil find that it is a great rest to the hand if they change from one size or shape of pencil to another whenever the hand grows tired. There is thus good reason why different sizes and shapes are made; it is not by any means all due to fad or fancy.

Pencils with colored leads are made in precisely the same manner as already described, except that the leads themselves consist chiefly of wax and coloring pigment, and therefore cannot be baked. They are, as it is natural to expect, made in rooms that are absolutely cut off from all connection with the graphite-pencil departments, for fear of their bright tints being discolored. In past years one of the greatest drawbacks with red and blue and other colored pencils was the tendency of the leads to break and crumble; it was next to impossible to maintain any kind of point; if graphite leads were brittle and friable, the colored ones were ten times worse. All this is now done away with, and the colored leads are almost as strong and tough as the graphite.

I have already mentioned the variety of rubber ends attached to pencils. In addition to these, The Dixon Company make a special combined rubber and eraser, suitable for carrying in the vest pocket. It is similar in appearance to a pencil, but instead of being loaded with graphite, one end is filled with pencil rubber and the other with ink eraser, about ⅜ inch in diameter. As either end wears down to the wood it can be sharpened like an ordinary pencil; for general office use, this is the neatest thing I have seen. With artists the choice of rubber is an important matter; speaking generally, the softer the pencil, the softer the rubber should be; and a rubber should never be so hard as to injure the surface of the paper.

RANGE FINDERS.

Ernest K. Roden.

SOME OF THE PRINCIPLES ON WHICH THEY ARE CONSTRUCTED—DESCRIPTION AND EXPLANATION OF THE INSTRUMENT NOW USED ON UNITED STATES SHIPS OF WAR.

THE measuring by an observer of his linear distance from a visible object, which for some reason is inaccessible or temporarily unapproachable, has always been a problem of more or less complicacy; but in this, as in many other ways, human ingenuity has come to the rescue, and, with the aid of scientific knowledge, has simplified matters to a wonderful degree.

Before entering upon a description of the range finder proper, it may not be out of the way to mention some of the principles on which instruments for measuring distances are constructed. Of these there are several, among which the following are prominent:

1. The visual angle subtended by objects of known height.
2. The velocity of sound.
3. The instrument its own base line, and the two adjacent angles known.

The term "range finder," or what has the same meaning, "distance finder," is also applied to instruments used to solve a triangle of which the base is obtained by outside means. Range finders constructed on the visual-angle principle have been known for many years. Boulanger's telemeter (this word is derived from the Greek *tele*, "far," and *meter*, "to measure") is constructed on the second of the three principles mentioned—the velocity of sound—and is peculiar and quite interesting. It consists of a glass tube about 6 inches in length, closed at both ends

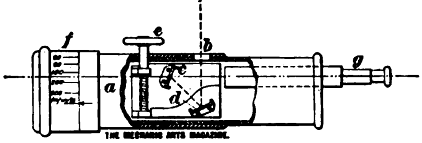


FIG. 1.

and filled with a transparent liquid which does not freeze at any ordinarily low temperatures. In the liquid is a metallic disk, free to sink from one end of the tube to the other, and so adjusted that its motion will be uniform and comparatively slow. The tube is enclosed in a brass case, to which is attached a scale after the fashion of that on a thermometer; this scale is marked for each hundred yards up to 4,000, and the divisions on it show the distance in yards through which sound will travel in air during the time required for the disk to descend over the space on the scale marked by the corresponding number of yards. In use, the instrument is held vertically, or as nearly so as possible; while in this position the disk slowly sinks toward the lower end of the tube. To arrest the movement of the disk at any moment, the instrument is quickly turned to a horizontal position. To determine with it the flight of shells during a bombardment or during target practice, it is held in the right hand, the palm of the hand down, with the zero of the instrument to the left; a turn of the wrist to the right brings the instrument vertical, with the zero end uppermost; the disk then descends, and a turn of the wrist to the left arrests its motion. The observer, holding the instrument as described, watches for the flash of the shell as it explodes, and upon seeing it, instantly brings the instrument to a vertical position; upon hearing the report of the exploding shell he instantly turns it back again. The position of the disk then indicates the number of yards from the observer to the place where the shell exploded. To ascertain the distance to an enemy's battery on land or to a hostile ship at sea, the instrument is held and turned in the same manner. The observer watches for the flash of the gun, observing which he turns the instrument vertical, and when he hears the report he turns it back and reads off the distance.

The telemeter invented by Capt. A. Gautier, of the French Artillery, is an instrument for measuring with considerable accuracy the distance to any object by viewing it from different points on a base line running in a direction transverse to that of the object from the observer. This instrument, in its simplicity, accuracy, and portability, recommends itself in all cases where a knowledge of a distance is desired at any moment with the least possible delay, such, for instance, as when range finding for a gunner, or when river crossing, or reconnoitering. A slight acquaintance with its use enables the observer to estimate with more than ordinary promptness and

precision the distance which it might be all important to obtain.

The instrument, a part section of which is shown in Fig. 1, resembles in shape and size one barrel of an ordinary field glass. It consists of a tube *a* having an opening *b* at one side, and containing two mirrors set normally at an angle of 45°, as shown; one of these mirrors *c* is fixed, while the other *d* admits of a slight movement by means of a thumbscrew *e*; thus, its operation is similar to that of the sextant. A ring *f*, turning on the axis of the instrument, carries a prism through which an object may be viewed by direct vision. To measure a distance from any object, the observer selects some other distant but well-defined object that is in such a position that the line drawn from it to himself makes approximately a right angle with the line drawn from himself to the first object whose distance is to be determined; and having brought the zero or infinite line on the ring opposite the arrow point on the tube, he views the selected object, or *natural signal*, as it is generally called, by direct vision through the eye tube *g*, looking over both mirrors and through the prism. By turning the screw *e*, the image of the object whose distance is sought, and the rays from which, passing through the opening *b*, are reflected from *d* to *c* and thence to the eye, is brought into coincidence with the natural signal. He then steps back some known distance, say 20 yards, along the line, passing through the first station (the first station is the position from which the first observation is made) and the natural signal. This distance, which serves as a base line, should not be less than one-hundredth of that of the station from the object whose distance is sought. The reflected image will now no longer coincide with the natural signal as seen by direct vision through the prism; but, by turning the ring *f*, the prism is rotated until its refraction again causes the two images to coincide. The ring is provided with a graduated scale containing a series of factors by which the length of the base must be multiplied in order to obtain the required distance, or range. The factor that stands opposite the arrow on the tube is the proper multiplier. These factors are derived by a simple calculation from the trigonometrical properties of a triangle supposed to be right-angled at the first station. Should the first and the second station, however, not be precisely in line with the natural signal, a correction may be applied according to the angular variation; but this correction is so small within the limits of angular measurements, which is about 3°, as to be neglected in ordinary practice.

Another range finder, the Berdan's, is an expensive instrument, constructed on the third principle, the instrument being its own base line. It is mounted on a wagon, and is intended to accompany either infantry or artillery. It has found great favor among the military powers of Europe, and for some years back was used extensively at the grand military maneuvers in France and Russia.

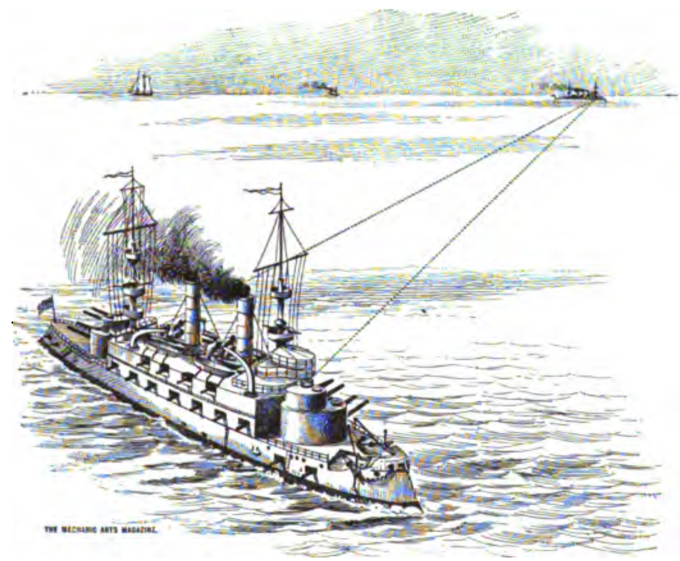


FIG. 2.

On board a man-of-war the range finder plays a particularly important role; it is, indeed, indispensable; without it the gunner would be badly handicapped, since the correct elevation of a gun can be determined only when the distance to the target is known. A century or two ago, when range finders were as great a mystery as the Keely motor has been to some of us, the

man at the gun had to rely solely on his ability to guess the distance, and elevated the gun accordingly; if the shot passed over its intended target, the gunner decreased the elevation, while if it fell short he increased it. This, of course, was fairly satisfactory in those times, when a few shots more or less made no particular impression on the supply in the ship's magazine; but nowadays, with the introduction of heavy ordnance and costly charges, any method of guessing the distance is altogether out of the question.

Among the best known range finders now in use on ships of war is the one invented by Lieut. Fiske, U. S. N. It is based on the same principle as Capt. Gautier's telemeter, making use of one side and the two adjacent angles of a triangle. In this case, however, *two* instruments are used, one at each "station"—the stations being, of course, situated at different parts of the ship, and the distance between them, which is accurately known, constituting the base line. Now, it is evident that, during a naval engagement, it is no easy matter to calculate a distance when the enemy's ship as well as your own is constantly moving and the angles, therefore, changing continually; besides, during the hurry and slaughter of a sea fight, the time that can be spared for making computations is exceedingly limited. In order to overcome these obstacles, Lieut. Fiske connected the two range finders electrically, by placing them in the circuit of a Wheatstone bridge, and caused the change of the two angles to record the distance of the object on the graduated scale of a delicate galvanometer. All that the observers have now to do is to keep the cross-hairs of the telescopes attached to their instruments upon the same point of the hostile ship, and the electric current translates the angles into the corresponding distance by the movement of a needle over an arc graduated into hundreds and thousands of yards. The following description shows the arrangement and method of operating the Fiske range finder.

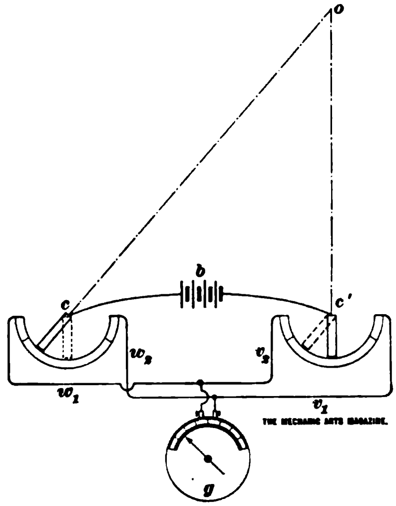


FIG. 3.

FIG. 4.

A powerful telescope is mounted on a standard so as to rotate in a horizontal plane above a graduated disk. Upon this disk is fastened a circular metallic strip, which extends an equal distance on each side of the zero graduation. Fixed to the telescope standard is a contact strip, which rotates with the telescope and slides over the circular strip on the disk. Fig. 3 represents a diagram of the two range finders, rotating about the centers c and c' of two disks. The terminals of an electric battery b are connected to the centers c and c', and the electric current flows through the contact strips on the standards to the metallic arcs on the disks, thence by way of the wires w_1 w_2, and v_1 v_2 to the galvanometer g. When the telescopes are parallel, the electric pressure on the terminals of the galvanometer are equal, hence no current flows through it and no deflection of the needle is produced. If, however, the telescopes are not parallel, then the electric pressure on the galvanometer terminals are not equal and a current will flow through the galvanometer, causing the needle to deflect. Suppose that the two telescopes are pointing at an object o. The arc through which the telescope on the left has been rotated from its mid-position being proportional to the angle c o c', it follows that the deflection of the galvanometer needle will be

proportional to the same angle, or to the distance *c o*. As stated, the galvanometer is graduated in hundreds and thousands of yards, and the distance in yards of the object *o* from the range finder is thus read off the galvanometer direct. One of these galvanometers is placed at each of the principal gun stations, as well as in the conning tower. The range finders are permanent fixtures, being placed in well selected positions which insure the operator a free view. Fig. 2 represents a modern man-of-war about to open fire upon a hostile ship; the converging lines drawn from each of the range finders will give the reader a clear idea of the operations of this most ingenious instrument. To avoid errors, such as the operators turning their respective telescopes towards different objects, the two finders are connected by telephone; each operator on applying his eye to the telescope has opposite his mouth a telephone transmitter, while a receiver is attached to his ear, as in Fig. 4. A constant communication insuring simultaneous observations is thus established.

Besides the instruments here mentioned, there are several others, such as the Gordon's, Rolan's, and Watkins's range finders; descriptions of them would, however, be but repetitions of the above, since the principles on which they are constructed are similar to those already described.

THE LEGISLATOR OF THE STARS.

(*Concluded from July, 1899, Number.*)

George McC. Robson, M. A.

KEPLER'S STUDY OF THE PLANET MARS AND HIS MUSIC OF THE SPHERES—ASTROLOGY AND SORCERY—LAWS OF THE SOLAR SYSTEM—KEPLER'S SPECULATIONS ON GRAVITY.

IN THE year 1601 Kepler accepted a position in Tycho's observatory; and Tycho, in dividing the work among his assistants, assigned to Kepler the planet Mars. On Tycho's death, in 1602, Kepler was appointed Imperial Mathematician, as successor to Tycho. Though the Emperor Rudolph was politically weak and foolish, he deserves great credit for the help he gave to Tycho and Kepler, and it is fitting that his name should be perpetuated in connection with the "Rudolphine Tables." These tables, published in 1627, were worked out in detail by Kepler from the records of Tycho's observations; for almost a century they were the standard tables, and were relied upon for the information that we now seek in the Nautical Almanac.

In the early years of the seventeenth century two discoveries, of the utmost importance to astronomy, were made—Galileo constructed a telescope and Napier discovered the method of calculating by logarithms. Kepler was one of the first that had the privilege of viewing the stars through a telescope; but the telescope, which has played such an important part in the development of modern astronomy, was of absolutely no use to Kepler—his talents and his work lay in a field where the telescope could not aid him. On the other hand, logarithms were almost indispensable to him, and his zeal and reputation did much to spread their use on the continent of Europe; he himself published tables of logarithms in 1625 and 1629.

Kepler now entered in earnest upon his life work, which was to free astronomy from the complexity of cycles, epicycles, and eccentrics that encumbered the Ptolemaic system and had been retained by Copernicus. No person, that has not tried to follow out in detail the explanation of the planetary motions in the Ptolemaic system, can appreciate the complexity of it. No wonder Milton, in Paradise Lost, says:

> "He his fabric of the heavens
> Hath left to their disputes, perhaps to move
> His laughter at their quaint opinions wide;
> Hereafter, when they come to model heaven
> And calculate the stars, how will they wield
> The mighty frame! how build, unbuild, contrive,
> To save appearances! how gird the sphere
> With centric and eccentric scribbled o'er
> Cycle and epicyle, orb in orb."

When this system was explained to King Alfonso X, of Castile, he exclaimed that if God had consulted him at the creation, the universe would have been on a better and simpler plan.

Kepler had secured the greater part of Tycho's records, and he set about discovering the laws of planetary motion by first making the best guess he could and then trying if the consequences of his assumed law would agree with Tycho's observations. In making

his guesses it was inevitable that he should be guided and influenced by the views that were unanimously held by his predecessors and contemporaries, and therefore he first tried all manner of schemes for representing the motion of a planet by uniform motion in a circle. He selected the planet Mars as the special object of investigation, and after many trials he got a scheme of uniform circular motion such that the place of the planet given by his calculation differed from that recorded by Tycho by only 8′. Any of the preceding astronomers would have been perfectly satisfied with such close agreement, but Kepler says "Since the divine goodness has given to us in Tycho Brahe a most careful observer, from whose observations the error of 8′ is shown in this calculation, it is right that we should with gratitude recognize and make use of the gift of God. For if I could have treated 8′ of longitude as negligible I should have already corrected sufficiently my hypothesis. But as they could not be neglected, these 8′ alone have led the way toward the complete reformation of astronomy and have been made the subject matter of a great part of this book."

He was thus compelled to give up the idea of uniform motion in a circle, and after several fruitless attempts, he eventually tried the law of the equable description of areas in a circular orbit; that is, *the line joining the planet to the sun sweeps over equal areas in any two equal intervals of time.* This theory fitted beautifully and he felt that he had conquered the planet, but very soon the planet broke out in a new place. He says "while I was triumphing over Mars and preparing for him, as for one already vanquished, tabular prisons and equated eccentric fetters, it is buzzed here and there that the victory is vain, and that the war is waging anew as violently as before. For the enemy left at home a despised captive, has burst all chains of the equations and broken forth from the prison of the tables."

However, Kepler had grasped part of the truth, and arrived at the law of the equable description of areas, which is now known as Kepler's second law. Having failed to effect a complete solution of his problem by circular orbits, he resolved to try oval orbits. The calculations, which in circular orbits were enormously laborious, were incomparably more formidable for oval orbits; and worst of all, in oval orbits the law of equal areas seemed to fail. Pondering on this difficulty, he was roused as if from sleep by the correspondence of certain numbers, which in some way that cannot now be explained suggested to him a new scheme, which after long calculation he found to represent the planet's motion very closely. This motion was very complicated, and on further investigation he found that it could be represented by making *the planet's orbit an ellipse having the sun in one focus.* This is now known as Kepler's first law. To his great joy, he found that in the elliptic orbit the law of equal areas also held. In Fig. 1 is reproduced the triumphant sketch made by Kepler on the diagram he used to demonstrate his law. Kepler now appealed to the Emperor for the sinews of war to make an attack on Mars' father Jupiter, his brother Mercury, and the rest of his family. Just at this time the emperor died, and Kepler was left in want and poverty.

To add to Kepler's distress at this crisis, his mother was charged with sorcery, put in

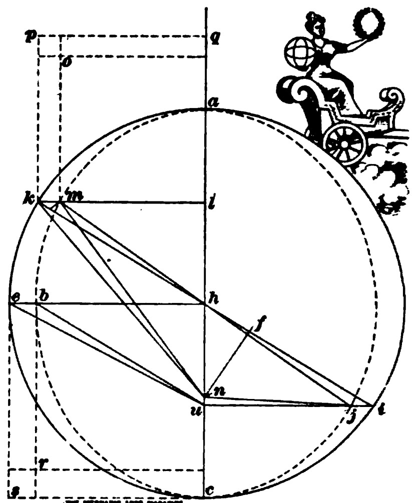


FIG. 1.

prison, and condemned to torture. Kepler hurried to Würtemberg to her assistance and saved her from torture, and she died soon after, at the age of eighty.

Kepler now devoted all his energies to discover a relation among the distances of the planets from the sun and their times of revolution about the sun. Finally, he obtained the very important relation, now known as Kepler's third law: *The squares of the times of revolution of any two planets about the sun are proportional to the cubes of their mean distances from the sun.* We seem to come very close to him in sympathy as we listen to his triumphant rhapsody,

"What I prophesied two and twenty years ago, as soon as I discovered the five regular solids in the heavenly orbits, what I firmly believed before I had seen Ptolemy's Harmonies, what I promised my friends in the title of this book, which I named before I was sure of my discovery, what sixteen years ago I urged as a thing to be sought, that for which I joined Tycho Brahe, for which I settled in Prague, for which I devoted the best years of my life to astronomical calculations, at length I have brought to light, and recognized its truth beyond my most sanguine expectations. Nothing holds me. I will indulge my sacred fury; I will triumph over mankind by the honest confession that I have stolen the golden vases of the Egyptians to build up a tabernacle for my god far away from the confines of Egypt. If you forgive me, I rejoice; if you are angry, I can bear it; the die is cast, the book is written, to be read either now or by posterity, I care not which; it may well wait a century for a reader, as God has waited six thousand years for an observer." Lest we should regard these as the unmeasured words of an excitable man in his hour of triumph, let us hear the impartial verdict of the nineteenth century. "When we consider," says Sir John Herschel, "the constituents of the planetary system from the standpoint which this relation affords us, it is no longer mere analogy which strikes us. . . . . . . The resemblance is now perceived to be a true *family* likeness; they are bound up in one chain, interwoven in one web of mutual relation and harmonious agreement; subject to one pervading influence which extends from the center to the farthest limits of the great system of which all of them, the earth included, must henceforth be regarded as members."

In a total eclipse of the sun the dark body of the moon is surrounded by a bright *corona* similar in shape and relative size to the aureole which artists paint round the heads of saints; Kepler was the first to consider this phenomena scientifically. He never saw a total solar eclipse himself. But he examined the records of an eclipse seen by Clavius at Rome, in 1567, and showed from the positions of the sun, earth, and moon that it could not have been an annular eclipse, as had been supposed on account of the dazzling brilliancy of the corona. He concluded that the "flame-like splendor" seen on such occasions was caused by the reflection of solar rays from matter floating near the sun or moon; he gave his preference to the idea that the matter was in the neighborhood of the sun, but he added that the theory should be laid by, ready for use, and not brought into immediate use. This theory—which is practically correct—only emerged from the limbo of buried truths after two centuries and a half of complete oblivion.

Reference has already been made to the fanciful character of Kepler's thoughts. He alone of astronomers has had the boldness to write down the music of the spheres (Fig. 2). He says the earth sings MI, FA, MI, so that you may guess that in this abode of ours Misery and Famine prevail.

The Copernican system, as well as the Ptolemaic, had required many revolutions about mere geometrical points; but Kepler's system involved only revolutions about actual bodies, the planets revolving about the sun, and the satellites about the planets. He naturally sought for some connection between

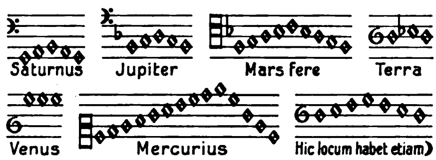


FIG 2.

these revolutions and the central body. In the preface of his "New Astronomy, or Celestial Physics," published in 1609, he speaks of gravity as of a power mutual between two bodies, and says that the earth and moon tend towards each other and would come together at a point as many times nearer to the earth than the moon, as the earth is greater than the moon, if their motions did not prevent it. He attributes the tides to the gravity of the waters towards the moon. His knowledge of mathematics was insufficient to enable him to work out the theory; indeed, the mathematics requisite for that great problem had yet to be created by a greater than he. Subsequently he formed other speculations in reference to gravity, and in his "Epitome of Copernican Astronomy," published in 1618, he has a further discussion of this subject. He had read William Gilbert's book on the Magnet, and the property of magnetic attraction suggested to him an analogy. He imagined that the planets might be thus connected with the sun, and share the sun's motion of rotation. He supposed that some "carrying virtue" spread out from the sun and tried to carry the planets round the sun.

"There is, therefore, a conflict," he says, "between the carrying power of the sun and the impotence or material sluggishness (inertia) of the planet, and each enjoys some measure of victory. The former moves the planet from its place, and the latter frees the planet's body to some extent from the bonds in which it is thus held."

MONUMENT COMMEMORATING PUBLICATION OF RUDOLPHINE TABLES.

After the lapse of centuries many estimable people feel called upon mildly to reprove Kepler for discovering truth through conjectures so wild and groundless; they are shocked that he should not have proceeded to discover his laws on the true Baconian principles. But it should be remembered that many of Kepler's guesses now appear ludicrous because we stand upon the vantage ground he won for us; others, that to his contemporaries appeared even wilder, appear to us marvelously sagacious — for example, his assertion of the rotation of the sun before it had been revealed by the telescope, and his declaration that the obliquity of the ecliptic was decreasing and would continue to decrease for a long period and then begin to increase. If an investigator at any period will be as careful as Kepler was to base all his speculations upon the best thought and knowledge available to him, and if he will exercise the same tireless patience and perseverance in testing his work before launching crude theories upon the world, he will rise very nearly to the stature of a great man; for it is a half truth—though not a whole truth—that genius is an infinite capacity for taking pains. Kepler displayed the true features of the scientific mind—boldness in speculation and indomitable perseverance in testing what had been suggested, and above all that absolutely necessary characteristic of the scientific mind which makes it impossible to be satisfied but with the very best. Any one of Kepler's theories would have been accepted without scruple by his scientific contemporaries, but Kepler tested them all and sacrificed remorselessly, one after another, the theories on which he had labored for years. Nineteen he rejected but the twentieth was the correct theory of the universe. It seems to us that in Kepler we see the true features of the scientific spirit, but we do not imagine that any two heroes of science are exactly alike in mind and spirit any more than in face; nor do we pretend to lay down any rules to guide those who seek to discover scientific truth. There is no royal road for inventing hypotheses. The inventor of an hypothesis, if asked to explain his method, might answer as did Zerah Colburn when asked to explain his mode of instantaneous calculation; when the child was worried by being pressed for the explanation, he cried "God put it into my head and I cannot put it into yours."

Kepler's astronomical discoveries have, to a large extent, overshadowed his work in pure mathematics; yet his contributions to the doctrine of the infinite and the infinitesimal and his clear enunciation of the important principle of continuity give him a high place among the founders of modern geometry. As an example of the law of continuity, Kepler pointed out that the parabola is at once the limiting case of the hyperbola and the ellipse. From this conception of the parabola as a limiting case of the ellipse, he was led to the principle that parallel lines must be regarded as meeting at infinity. Among Kepler's minor contributions to geometry is the now common method of describing an ellipse by passing a loop of thread around two pins fixed at the foci; he also gave the corresponding constructions for the parabola and the hyperbola. Geometry is also indebted to him for the name *focus*, which he adopted into Geometry from the science of Optics.

A HOME-MADE BUNSEN BURNER.

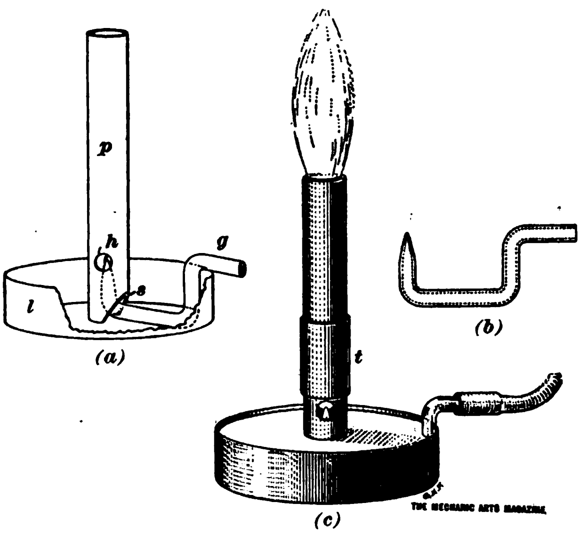
Prof. Richard K. Meade.

WHAT A BUNSEN BURNER IS, AND HOW TO MAKE A THOROUGHLY SATISFACTORY ONE AT A COST OF BUT A FEW CENTS.

THE following description of a cheap form of Bunsen burner may be of use to those students of science whose pocketbooks and stock of apparatus do not keep pace with their thirst for knowledge, or to those teachers who are expected to demonstrate the wonders of chemistry or physics on a very limited allowance for apparatus. The burner described will also prove convenient in the workshop for heating soldering irons, etc., and in the home for warming shaving water or curling tongs.

A Bunsen burner is simply a tube so arranged as to admit both illuminating gas and air, and to allow them to mix before reaching the opening where they are fired. When ordinary illuminating gas is burned in this manner, all the carbon is consumed, and a flame free from soot, and much hotter than the ordinary "fish-tail," results.

To make such a burner, select a piece of glass tubing of from $\frac{1}{4}$ to $\frac{5}{16}$ inch external diameter, and bend it in the form shown at (*b*). To do this, revolve the tubing slowly in the flame of an ordinary gas jet (burning at not quite its full capacity) until the glass softens, when the tube may be bent to the desired shape. Make each bend separately. Now, to make the tapered end *j*, turn the gas jet to its full capacity and revolve the tubing across and at right angles to the flame. When the glass softens, remove from the flame and pull apart, thus getting the jet *j*. Break the tube where the tapered part is about $\frac{1}{16}$ inch internal diameter. To do this, scratch with a file at the desired point and, placing the thumbs opposite the scratch, break the tube. The end *r* should be rounded by holding in the gas jet until the glass just fuses.



Procure a piece of brass tubing *p*, in (*a*), from $4\frac{1}{2}$ to 5 inches long, and not over $\frac{3}{8}$ inch internal diameter, yet large enough to pass over the glass tube in the manner shown. Stand this beside the glass tube and mark the height to which the jet *j* reaches. File two round $\frac{3}{16}$-inch holes *h* opposite each other in the tube at this point, and file off the same end of the tube at an angle, as shown at *s*, so as to allow the bottom of the brass tube to rest on the table when slipped over glass jet.

Now set the glass tube, with the brass tube slipped over it, in a tin shoe-polish box *l* or the top of a round tin box, in the position shown in (*a*), and pour plaster of Paris (made into a paste with water) around the tube, so as to nearly fill the tray. Secure everything in position until the plaster sets hard, when the burner is complete, as at (*c*). It is to be attached to the gas jet by a piece of rubber tubing.

If it is desired to regulate the air supply, this may be done by means of a sleeve *t* of tin or sheet brass, or a piece of light tubing split so as to spring on to the main tube. Such a burner may be made for only a few cents where the materials have to be purchased, and often, at the expense of time alone, from scraps around the workshop or laboratory.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

Samoa.

IN GENERAL characteristics the Samoan group resembles the other coral islands with which the southern Pacific is thickly sown. Only four of the islands are large enough to be of importance; the others are rocky islets of a few hundred acres in extent. Each one is surrounded at a little distance by a coral reef with one or two openings, which admit the passage of vessels; but the harbors, with one exception, are poor, and afford little shelter from the hurricanes of the tropics. They are rich in natural beauty, and the soil is extremely fertile. All that is needed for the support of life is procured in abundance with very little labor. The inhabitants are of the best type of the Polynesian race, possessing a fine physique and many admirable traits of character. They respond readily to the advances of those who treat them with kindness and justice, and accept within certain narrow limits the customs of the white races who settle among them.

The direct commercial value of the group is small, but its position gives it a strategic importance recognized by all the Powers which concern themselves with Samoan affairs. It lies in the direct trade route from Australia and New Zealand to the Pacific coast of the North American continent. A line from New Zealand to the Hawaiian Islands, and thence to San Francisco or to British North America, passes through the Samoan group. Vessels sailing from Sydney or Melbourne to Atlantic ports or to Europe, via the interoceanic canal of Panama or Nicaragua (whenever it becomes a fact), will pass within easy call of Samoa. It would be one of the natural stations of the Pacific submarine cable, which must be laid in the near future, either by the United States or by Great Britain and her colonies in Canada and Australia. What better spot could be fixed on as a naval depot or as a coaling station by the nations who have commercial or territorial interests to protect by means of warships patrolling the Pacific ocean?

America has a coaling station at Pago Pago, on the island of Tutuila, the one really good harbor in the Samoan group. Nearly thirty years ago a Samoan chief offered to cede this harbor to the United States, but the treaty with regard to it was not ratified by the senate. Another treaty was concluded with Samoa in 1879, after its independence had been recognized, but even then America did not accept exclusive rights to Pago Pago. Her position, however, as a great Pacific power, is fully acknowleged, and any claim which she might make to Pago Pago would probably be conceded by other nations. Great Britain has a close interest in the affairs of the Samoan Islands, partly on account of the nearness of her Australian colonies, and more than fifty per cent. of the few white residents are British subjects.

The voice of Germany is also influential in Samoa. Many years ago a German trading firm settled at Apia, and thence exported the produce of the islands. As far as exports are concerned, German interests exceed those of other Powers; but more than fifty per cent. of the imports of Samoa in 1897 were from Great Britain and her colonies, twenty-five per cent. from Germany, and fifteen per cent. from the United States, while the carrying trade is mainly in British hands. It is well known that Bismarck, who at one stage of German history opposed the idea of acquiring colonies, became at a later date an ardent supporter of the colonial party. He lent the weight of government influence to the German firm which had settled in Samoa, thinking perhaps of the small trading company which laid the foundations of the British power in India three centuries ago. But the interests of the United States and Great Britain were at stake, and they opposed the plan of making Samoa a German colony.

The Samoans themselves do not desire annexation to Germany. They see their own weakness, and their leading men recognize that foreign interference combined with native jealousies prevent them from carrying on a stable government. But the German traders who are established in the islands employ native labor on their plantations, and in their dealings they are inclined to use the strict discipline which when applied to their own people has produced the finest army in Europe, but which strikes terror to the Samoan heart. It is of no use to exact strict obedience, industry, and order from natives of the tropics, whose semicivilization is still in its infancy, and has not had time to mold the

national character. The Samoans rebel against such rule as against oppression and tyranny. They expect to be controlled eventually by one or other of the three Powers who have disputed about them for so long, and see that only under such protection are they likely to be left at peace. Petitions for annexation have been sent to Great Britain and to the United States at different times, but political difficulties have intervened.

The dissension between the three Powers which claim a voice in the settlement of Samoan affairs came to a head in the winter of 1888–89. American, British, and German warships lay like watch dogs in the harbor of Apia, on the island of Upolu, and a fight seemed imminent. But nature called a halt in a very effective manner. A violent hurricane of many hours' duration drove the vessels from their moorings, dashed them against one another or on to the reefs, and destroyed them all, except the British ship Calliope, which steamed out of the harbor in the teeth of the gale, cheered by American blue-jackets on the decks of their own helpless vessel. This happened in March, 1889, and in the following summer a conference met in Berlin at which an agreement was reached on the Samoan question. Samoa was not represented at the conference, nor was she consulted about the treaty which was concluded between the Powers. This treaty guaranteed the neutrality and the (so-called) independence of the Samoan government, with the right to elect a king according to its own national customs. One royal candidate, Mataafa, was declared ineligible for election on account of past difficulties between him and Germany. The treaty created a supreme court, to which all questions with regard to the rights of the king must be referred for decision. The chief justice of this court must be appointed by agreement of the three Powers. Judge William L. Chambers, of South Carolina, is now the incumbent of that office. Regulations were made for imports and customs, and for the sale of lands; traffic in intoxicants and in firearms (with exceptions) was prohibited; and special provision was made for the government of the municipality of Apia, where is assembled the bulk of the white population. It is an international port, and is governed by a white magistrate, who at the present time is a German. Even on paper this seems a complicated scheme for the government of a little group of islands, and it need hardly be said that it has proved to be a failure. The king, at the head of the native government, is nominally independent, but he can have little real authority. There is a president of the municipal council as an advisor, a chief justice as a court of last resort, and three foreign consuls with ill-defined powers, whose principal concern must be to protect the interests of their respective countries, while Samoa occupies the second place in their minds.

The Samoan king died last summer, and trouble arose about the election of his successor. Malietoa, the heir of the late king, was chosen by one party and was declared to be duly elected. Mataafa, who had returned to the islands after many years of banishment, had many more supporters. He is the idol of the people, and by character and circumstance is well fitted to rule. Chief Justice Chambers decided that in accordance with the provisions of the treaty of Berlin he was ineligible. The German officials opposed the American chief justice, and supported Mataafa's claims, and the two parties came to blows. The American and British forces stood side by side in defense of the arrangements which the chief justice declared to be lawful, and which the Powers were pledged to support. Samoan villages were bombarded by ships of war, and the islands were in a state of anarchy. Mataafa with an armed force was unable to maintain peace, although he was successful over his native rival when they met in battle. His supporters refused to recognize the authority of the chief justice.

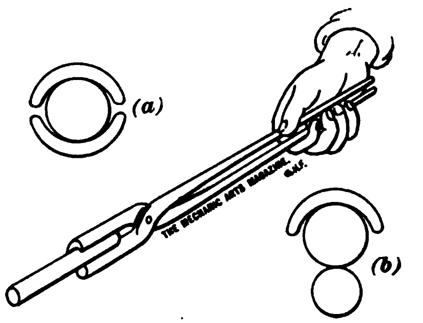
The situation was not creditable to the three Powers who had devised the system under which the islands were governed. Recognizing the need of interference for the protection both of the natives and of the foreign residents, commissioners were sent to Samoa who were to adjust the difficulty in a reasonable way. The Chief Justice has been reinstated in his position. One of the rival royal candidates for the throne has resigned his claims; the other is to be banished from the islands. The kingship is to be abolished, with the consent—real or nominal—of the islanders; and a Governor, approved by the Powers, be appointed in his place. There will also be a council of three members designated by the Powers, and representatives of the people are to form a kind of Legislature. At the time of writing the scheme still needs the consent of the governments represented by the commission, but it is hoped that a peaceful settlement is in sight.

GOOD SCHEMES

BLACKSMITHS' TONGS.

Machinist.

WHILE engaged last summer on fortification work on the southern coast, I noticed that the blacksmith used, instead of the usual tongs for holding round iron, a tongs made exactly like a curling iron. He said that this form of tongs not only did away with the necessity for having more than two

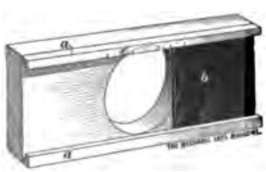


or three different sizes, but that in his opinion it also gave a better grip. Looking at the end of the tongs with piece gripped, his was as shown at (b) in the figure, instead of as at (a), as is usual.

DOUBLE-EXPOSURE HOOD.

Kodaker.

IN THE June number of THE MECHANIC ARTS MAGAZINE, S. J. Routledge tells how he obtained a double photograph. A better, and I think a simpler, method of arranging the lens hood for this purpose is as follows: In the center of a piece of hard wood about ½ inch thick and three times as long as the lens is wide, bore a hole exactly the size of the lens tube. On the face of



this, glue or screw two guides, as shown at a, a in the figure, and under them fit a small slide b, made of either hard black rubber or blackened cardboard. On the upper guide a mark a number of divisions, as at e. To obtain a double photograph, focus the camera upon the subject, push slide b over the opening until half of the field is obscured; and note which of the divisions e the edge of the slide is under. Put in the plate-holder, and expose. Change the position of the subject, and push the slide b in the opposite direction to the same graduation; then expose as before. On developing, no line will show between the two exposures.

TO WRITE AND SKETCH WHILE TRAVELING.

Linwood C. Plummer, Fort Fairfield, Me.

HEREWITH I outline an idea that if once acted upon will become indispensable to those readers of THE MECHANIC ARTS MAGAZINE who wish to write or sketch while traveling in car, carriage, or any kind of boat. Take a light pine board (say ½ inch) 20 inches long by 30 inches wide, and dress it to the shape shown in Fig. 1. At a, a cut holes suitable for receiving a leather strap, and adjust the length of this strap so that, when passed around the neck as shown in

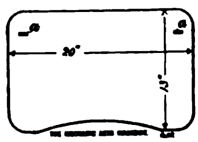


FIG. 1.

Fig. 2, the board will be at a convenient angle for writing upon, with the curved front edge resting against the lower chest. It will be found that, by using this portable board, writing and sketching can be done with as much accuracy while on a fast-moving car, on board ship, or on any vehicle, no matter how severely it vibrates, as if one were sitting on a fixed seat in front of a stationary desk. The reason for this is that, the board being supported entirely from the body, all vibrations are transmitted to it through the body, and therefore the vibrations of the board are in perfect unison with those of the body, and no vibrations whatever are apparent. And it is almost as valuable when reading as when writing or drawing; we all know how tiring it is to the eyes to read in a jolting, swaying car. During a vacation, too, while camping out, it will be found a friend in need, as letter or sketch can be written or drawn with the

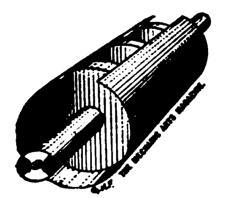
help of this little scheme, as well when seated on a fallen log as if seated in one's own drawing room. Again, the board is not altogether without usefulness at home. Seated in a high-backed rocker one may enjoy a complete physical rest, yet at the same time be reading, writing, or sketching; in this case, it is just as well to support the board from the top of the rocker back by passing the strap around same; then, the very slight pressure on the neck is removed.

FIG. 2.

A BABBITTING MANDREL.

Schemer.

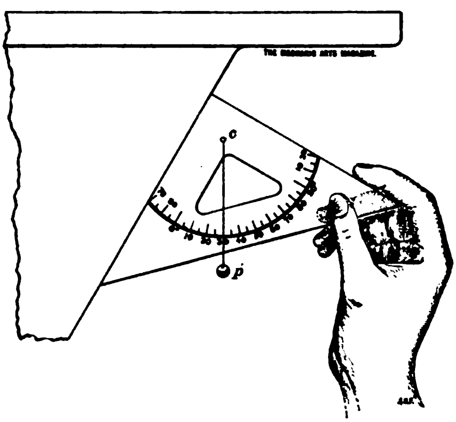
I FREQUENTLY have occasion to rebabbitt boxes for large shafting, engine journals, etc. As is well known, this is a tedious and particular job, it being necessary to have your temperatures just right in order to get a full run. To simplify the operation, I devised the mandrel illustrated herewith. From a 1-inch board I had cut a number of disks a trifle smaller in diameter than the journal to be babbitted; these I placed on a piece of small shafting *s*, the holes in the disks being exactly central and rather a tight fit on the shaft. After spacing these disks evenly, I bent around them a piece of sheet iron, cut to such a length that it would leave an open space at the top as shown, and I secured it to the disks with brads. This gave me a mandrel having a smooth surface and one that required no heating; it produced a smooth, solid bearing, and one upon which very little work had to be done. It is in every way a handy mandrel, inexpensive, and allows the pouring to be done in the most convenient place.



SURFACE ANGLE INDICATOR.

Richard J. Elliott, Tacoma, Wash.

WHILE working for the principal foundry in this city, I found that, when making drawings of castings from which it was desired to make patterns, if some device could be made such that, when held against the surface of the casting, it would tell approximately the angle which that surface made with the vertical, a great deal of time would be saved. I therefore contrived the instrument illustrated in the accompanying sketch. To make it: Take a 9-inch, 45°, celluloid triangle, and, choosing a point *c* in the right angle as center, with a pair of dividers scratch an arc of a circle from one edge of the triangle to the other, about as shown. Graduate this arc in degrees,



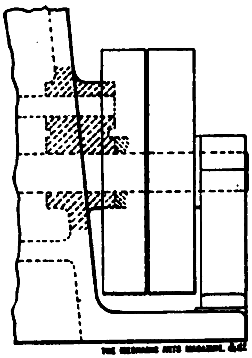
locating first the 0° mark and the 90° mark by scribing lines toward *c* parallel to the sides of the triangle. Mark the graduations as shown in the sketch; then pierce a hole through the triangle at *c* and hang from it a plumb-bob *p*; this bob may be easily made out of a lead shot, secured to the thread by nicking, inserting the thread in the nick, and closing the shot with a hammer.

The illustration shows the device in use, telling the draftsman instantly that the surface of the casting against which the device is held makes an angle of 30° with the vertical.

DOTTED SECTION LINING.

Cincinnati.

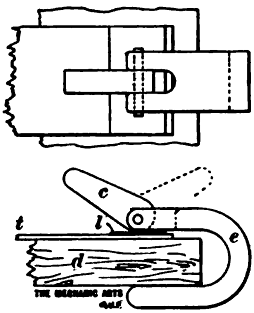
Some years ago a well-known firm in the East with whom I was then a draftsman, adopted the following plan: Whenever, in the draftsman's opinion, an assembled drawing could be improved by putting in a dotted outline of a section through any part, and then section-lining with *dotted* lines, he was expected to make this addition. The sketch here shows the principle of the thing. Many times this simple scheme saves the trouble of looking up detail drawings to find out an inside construction, and I can recommend the idea strongly to draftsmen and drafting rooms generally. It does not mar the assembled drawing—rather adds to the effectiveness of it, if anything—and it adds to the value of the drawing to the draftsman, giving as it does a clear idea of the general *construction* of the machine as well as of the mere outside appearance. I have tried many times during the past few years to introduce this idea, but only in one instance was I successful; the objection to it seems to be that it is an innovation, and the drafting room being naturally conservative, it is not acted upon, even though approved in principle. I think this is a pity, because judicious dotted sectioning at least doubles the practical value of the assembled drawing. In many cases, where it is desirable to send drawings to a prospective customer, one assembled drawing thus "picked out" with dotted sections answers the purpose of a bundle of ordinary drawings.



CLAMP FOR T SQUARE.

J. P. Pinney, Rogers, Ark.

I think the device illustrated herewith is simple and easily made, and forms an excellent clamp for temporarily securing T square to drawing board while section lining. It consists of only three parts: a U piece, a clamping lever, and a connecting pin common to both. In the sketch, which shows elevation and plan of the device, *d* is the drawing board, *t* the T square, *e* the U piece, *c* the clamping lever with one forked or bifurcated end, as shown in the plan, and a pin the hole for which is drilled through both while the lever is held eccentrically; *l* is a strip of leather glued to the T square, to take the pinch. To clamp, move the lever to the right until it occupies the position shown dotted in the sketch; its eccentricity causes it to press hard on the leather strip, and the spring of the U piece maintains a steady and secure grip on the T square and board, holding them firmly together while section lining or some similar operation is done. To make this clamp I took 4 inches of $\frac{3}{4}'' \times \frac{5}{16}''$ flat bar iron and bent it into the U piece; the lever I made of ¼-inch material, and the pin of ⅛-inch steel wire.

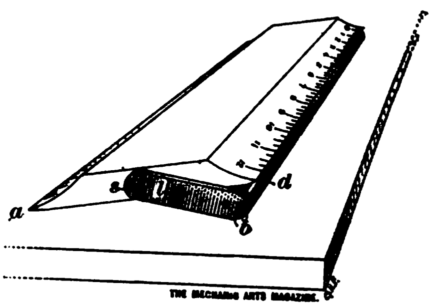


DRAFTSMENS' SCALE TILTER.

Chas. E. Montgomery, Boston, Mass.

The device illustrated in the accompanying figure may be of value to those draftsmen who use the flat boxwood scales in preference to the triangular ones.

It is difficult to find a flat scale that has



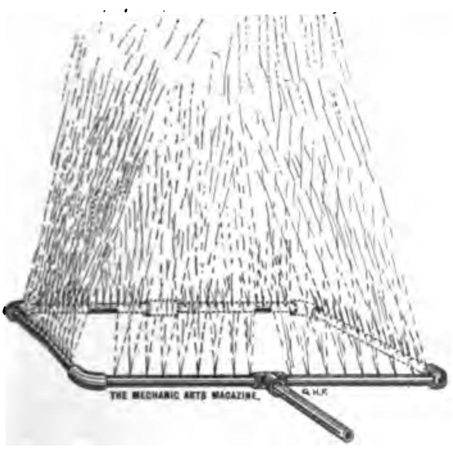
been in use for any length of time the edges of which do not curl upwards; this curling, shown at *a* in the figure, is particularly noticeable where the scale is faced with white celluloid, as many of the best are. In using such a scale it is necessary to tip up one edge in order to bring the other in contact with the paper, and this is a nuisance, not only

because it gives the left hand unnecessary work, but because it is almost impossible with such a scale to lay off dimensions accurately, the zero point being more likely than not to slip and cause the wrong dimension to be laid off. The illustration shows the manner in which this difficulty may be obviated; *d* is a circular rod of hard wood of such diameter as to give the desired slant to the scale. (I used a piece of ¼-inch birch dowel-pin.) At each end of this rod, which should be a trifle longer than the scale, is attached, by means of two brads *b*, a link *l*; these links may be filed out of brass plate, say $\frac{1}{32}$ inch thick. The other end of each link is pivoted to the center of one end of the scale by means of screw *s*, so that the whole attached part is free to swing and to be brought under either edge of the scale at will. With this device attached, the edge of the scale is always where it should be—down on the paper, and this form of scale becomes as easy to pick up and handle as its rival the triangular.

AN EMERGENCY STEAM BLOWER.

Burton B. Pierce, Uxbridge, Mass.

In many power plants there are sudden calls for a greater quantity of steam than the boiler can readily furnish, but, the call being for only a small part of the run, the fireman is left to "sweat it out" as best he can. The following simple device will aid any hard-pushed fireman in getting over the peak of his load: Take ½-inch pipe and



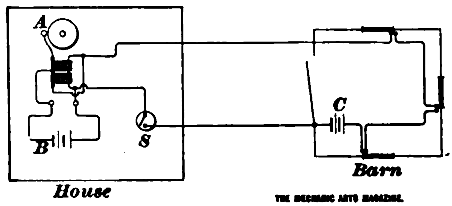
make a single coil to go just inside the riser from the boiler to the chimney and completely around it, the shape corresponding to that of the smokepipe. By means of a T connect this coil to a pipe passing through the side of the smokepipe, and through a valve connect this to the steam at boiler pressure. After the coil has been screwed up tight, drill $\frac{1}{16}$-inch holes all the way around it, about 2 inches apart and at such an angle with the vertical that the issuing jets of steam will meet in a point about 10 feet above the coil. This can be readily attached, and is to be used as occasion requires.

ELECTRIC BURGLAR ALARM.

Jackstone, Phillipsdale, R. I.

The scheme illustrated here is not exactly new, but it is a good one, nevertheless, and is not generally known.

It frequently happens that we wish to give our barns, hen houses, etc., some kind of



protection from thieves, and while we may have the ability to install a common electric-bell arrangement, the plan is usually rejected as unsatisfactory, because we know that if the wires are cut the apparatus will be rendered useless. The scheme here goes a little further, being such that the cutting of the wires as well as the opening of a door or window gives the alarm. An ordinary electric bell *A* is used in connection with an open-circuit battery *B*, and a closed-circuit battery *C*, both kinds being necessary. The open-circuit battery is connected to the binding screws in the ordinary way, except that no push button is used, the circuit being continuous. The closed-circuit battery is connected to the alarm connections and bell magnets, and when the alarm is set by closing the switch *S*, we have a continuous circuit without a break.

As this circuit is connected only to the bell magnets, it holds the armature away from the contact screw. Now, when a window or door is disturbed or a wire cut, the closed circuit is rendered inoperative, and this allows the armature to spring back and strike the contact screw, thus closing the circuit and causing the bell to ring until taken care of.

TRADE NOTES

THE STANDARD WELDING CO.

We have been advised that that part of the business of The Standard Tool Company, of Cleveland, Ohio, concerning seamless steel tubing, electric welding of bicycle parts, and general welding has been transferred to a new company to be known as The Standard Welding Co., with manufactory and offices at practically the same place as that of the first-named concern. The new company has increased its facilities for turning out work promptly.

In the latest catalogue of The Standard Tool Company just received, special attention is called to the drill illustrated here. The lubrication tubes are fitted to connect with a hole in the shank of the drill. The oil is forced in at the shank and flows through the tubes, thus giving a constant supply at the cutting edges. This drill can be used in screw machines or any machines that are fitted to give supply of oil. If desired, the inside of the hole in shank is threaded for pipe connections. The makers are prepared to supply these drills in all sizes from ⅜ inch up, and in any lengths.

JAP-A-LAC.

"Jap-a-lac" is the name of a new finish for either hard or soft woods, lately introduced by the Glidden Varnish Company, of Cleveland, Ohio. It can best be described as a quick-drying, glossy, transparent stain. Its absolute transparency, its brilliant gloss, and its great durability are claimed as its chief points of peculiar merit. Being transparent, the natural grain of the wood that it covers remains visible, and very beautiful effects can be obtained. It is made in eight colors: walnut, malachite (a rich green), ox-blood, black (both brilliant and dead), orange, mahogany, oak, and natural (for use where it is not desired to change the natural color of the wood). Jap-a-lac is also made in four solid, that is, non-transparent, colors: spruce, drab, yellow, and ivory. It is easy to apply, dries quickly, and is useful in a variety of ways about the house, as, for instance, for staining floors, and renovating old woodwork and furniture, especially wicker and porch furniture. It is sold in cans containing from ½ pint (25 cents) to 1 gallon ($2.50). 1 pint will give 2 coats to 25 square feet of surface.

Having tried this new wood covering, we can speak of it positively as the best and most durable finish we have ever seen for either hard or soft wood.

A NEW MAGAZINE FOR WHEELMEN.

"Elliott's Magazine" is the name of a new monthly publication with which will be combined the present weekly "L. A. W. Bulletin and Good Roads." The new publication, the first number of which will be the August issue, will retain the best features of the "Bulletin," which have made for the latter a large number of friends in all parts of the country, and will add much in the way of handsomely illustrated articles, stories, and special features of contemporaneous interest. It will be placed on the news stands. Its paid-in-advance subscription list will start with over 60,000 names. It is published in Boston, Mass.; editor, Sterling Elliott.

NEW BOOKS OF INTEREST.

Any of which can be obtained from The Technical Supply Co., Scranton, Pa.

"Marine Boilers." Their construction and working, dealing more especially with tubular boilers. L. E. Bertin. $7.50.

"Mechanics Applied to Engineering." J. Goodman. $2.00.

"A Practical Treatise on Modern Gas and Oil Engines." T. Grover. $2.00.

"Engine-Room Practice." A handbook for young marine engineers. J. G. Liversidge. $2.50.

"A Course of Practical Chemistry." M. M. Pattison Muir. $1.50.

"The Steam Engine and Gas and Oil Engines." A book for the use of students who have time to make experiments and calculations. J. Parry. $3.25.

ANSWERS TO INQUIRIES

Note.—Address all letters containing questions to be answered in this department to The Mechanic Arts Magazine, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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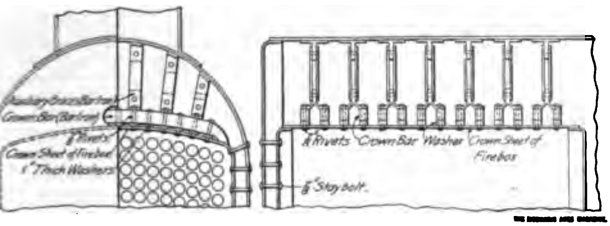
(154) I enclose drawing showing the crown sheet of the firebox of a locomotive boiler. As shown on the drawing, the radius of the arch is 9 ft. 5¾ in.; thickness of sheet, .47 inch, of steel having a tensile strength of from 55,000 to 60,000 pounds per square inch. The crown bars are of wrought iron; each has thirteen 1-inch-thick washers between it and the crown sheet. There are some auxiliary braces leading from the top of the crown bars to the shell of the boiler, but, irrespective of these, what is the sustaining value of one of these bars thus placed?

H. M. L., Pottstown, Pa.

Ans.—Practically, the crown bar may be considered as a uniformly loaded simple beam, whose span is the horizontal distance between the centers of the two end bearings on the crown sheet, about 60 inches. The net section of the bar, allowing for a 1-inch rivet hole, is 1 in. × 2¼ in. Assuming the safe working stress to be 12,000 pounds per square inch, the total uniformly distributed load that it will safely carry is



$$W = 8 \times \frac{12{,}000 \times 1 \times 2.25^2}{6 \times 60} = 1{,}350 \text{ pounds.}$$

This is but a very small fraction of the pressure that will come on that section of the crown sheet included between the center lines of two bars.

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(155) Kindly give and explain the principle upon which the terms of the divisor are inverted.

N. C. N., Orangeburg, S. C.

Ans.—When the fraction $\frac{7}{11}$ is divided by unity the quotient is $\frac{7}{11}$. But if the unit is separated into fifths and one of these fifths is taken as divisor, the quotient will be five times as great as before; that is, $\frac{7}{11}$ divided by $\frac{1}{5}$ is equal to five times $\frac{7}{11}$. If the second divisor is multiplied by 3 the divisor becomes $\frac{3}{5}$, and the quotient will be one-third of the quotient in the second case. Thus, $\frac{7}{11}$ divided by $\frac{3}{5}$ is equal to one-third of five times $\frac{7}{11}$, which is equal to $\frac{5}{3}$ of $\frac{7}{11}$, or $\frac{5}{3} \times \frac{7}{11}$. That is, $\frac{7}{11} \div \frac{3}{5} = \frac{5}{3} \times \frac{7}{11} = \frac{7}{11} \times \frac{5}{3}$. The same analysis applies to any case of division by a fraction; thus, we get the usual rule for division of fractions, viz., invert the divisor and proceed as in multiplication.

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(156) (*a*) How would you go about it to set the valves on a double engine using links? and common slide valves? (*b*) How are the sizes of the ports determined?

D. B. S., Columbus, Ind.

Ans.—(*a*) The first thing is to find the dead centers; this will involve moving the engine around. You do not say whether the engine is a stationary one or not; if it is, and is not yet coupled up to load, you can pull the flywheel or bandwheel around comparatively easily. If the main belt is on, do not take it off (especially if cemented and riveted), but turn the engine around by whatever appliance is provided for the purpose. If nothing better offers, you can pinch the crosshead along, putting in blocks of wood between the guides for the purpose. To find the dead centers, start with the right side first—it does not matter which—and pinch the engine around until the front face of crosshead wing comes to within about ¾ inch of the end of stroke; mark the position of the crosshead on the guide. Next, get a tram with one or both ends bent L-shaped, according to where you are going to set off from. You can use some part of the framing, or else you can set the tram on the floor itself—whichever is convenient. Whether you mark off on the edge or on the face, it will be as well to run a line around the wheel, using your trams and working from the center of the shaft in the first case, and using your hermaphrodites in the second. Make the arc extend a foot or two on each side of the point that your tram will touch when the crank is on the center. If you are using the edge of the belt pulley (or bandwheel) you need not do the above, as the edge of the rim will be quite narrow. Having marked the position of crosshead as before mentioned, scribe a line on the wheel rim with the tram; it is as well to set the tram on such a point of support as will bring it tangential to the wheel. Having done this, turn the engine around over the center until the crosshead comes opposite the mark on the guide once more; then scribe another mark with the tram. Next find the central point between the two tram marks, and set the engine so that the tram falls on that point; you will then have the crank on the dead center. A neater and more workmanlike proceeding is to use a small tram to mark the crosshead position; set one end on the guide block or stuffingbox, and with the other scribe on the side face of the crosshead wing. You must look out for lost motion. If you have much play in your main-rod brasses, you must pinch past the line and then pinch back until the crosshead is on the line again. Then you will have the same brass in contact with the wristpin each time. If there is any lost motion in the valve gear—either in the yoke or in the pins—you must take care of the same, or else your lead will be affected. Having set the

crank on the front center, you can proceed to try the valves over. Notch the engine up into her usual running position, and see what port opening you have. Then set the engine on the back center and see what the opening is there. Alter your eccentric-rod or valve-rod length (if the latter is adjustable) until the leads are equal; and then if there is too much lead set the eccentric back towards the crank the required amount, or if the lead is too little set the eccentric away from the crank. If a rocker is used that reverses the motion of the valves (as in locomotives), move the crank in the opposite direction to that above mentioned. If, however, the rocker has its fulcrum at one end, the motion of the valve is not reversed and the first instructions hold. Some people prefer to equalize the cut-offs. (You will find that if you have equalized the leads as above, the cut-off will not be the same at both ends of the cylinder.) Mark a point on the guide as many inches from the end of the stroke as you wish to cut off at—say, 12, for the sake of illustration. Then turn the engine around till the crosshead is opposite that mark, i. e., has moved 12 inches from the end of the stroke, and pull the reverse lever up till the front port closes. Then try the other end; perhaps that may be cutting off at 11½ inches; if so, you must lengthen the fore eccentric rod, or shorten it if the reverse rocker is in use, as in locomotives. See also that the engine carries her steam the same distance in both cylinders. If you cannot get it right in this respect, see whether your link hangers are the same length, or if either of your reverse shaft arms is sprung; also, see if the valves have the same travel, and the same amount of lap on corresponding ends. As regards finding the dead center, you can use your crosshead tram, and keep on lightly marking the crosshead as it nears the end of its travel, and put a prick mark on the last line thus made before she begins to reverse. That will tell you, in the future, when you are at the end of the stroke. This method is often followed; it works all right where there is no lost motion. (*b*) The size of ports depends chiefly on the piston speed, the matter of cut-off not entering largely into the question, because although with a late cut-off, there is more steam to be got rid of, yet the exhaust opening will then be both larger and of longer duration. However, you can use the following proportion: If the piston speed is about 200 feet a minute, make the area of the steam port $\frac{1}{25}$ that of the piston; if 300 feet, say, $\frac{1}{15}$; and for 600 feet about $\frac{1}{10}$. We assume, as you say nothing to the contrary, that you are dealing with stationary engines, where the speed is predetermined and constant, and also that the same port is used both for admission and exhaust. Having determined the area of the port, you next fix on its length. You can make it about $\frac{7}{8}$ of the diameter of the cylinder. The length determined, the width follows. A steam opening of about $\frac{3}{4}$ to $\frac{7}{8}$ of the port width will suffice for admission. The width of bridge should be made about the same as the thickness of cylinder. It may have to be wider, but do not make it less, or your casting will not be as good. If, when the links are dropped right down, there is considerable over travel, you must design the bridge accordingly—leaving a margin of $\frac{1}{4}$ to $\frac{3}{8}$ inch between the steam edge of valve and the edge of exhaust port.

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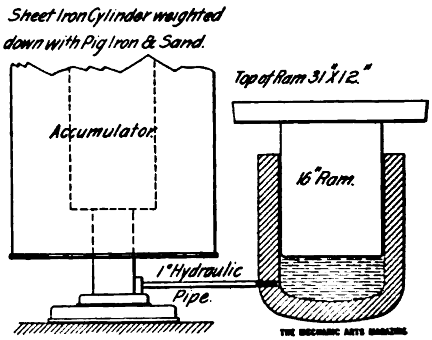
(157) Enclosed sketch represents an accumulator and ram for oil press. The accumulator is raised by a hydraulic pump; after being lifted 18 inches it trips a valve, when by its own weight it forces oil to the ram cylinder. Now, if there is a pressure of 4,000 pounds in the accumulator, and the oil is transmitted through a 1-inch hydraulic pipe to the 16-inch ram, the pressure on the latter should be 4,000 pounds per square inch. The top of the ram is 31 inches long by 12 inches wide. What is the pressure per square inch on this surface? Make the above clear to me by means of simple arithmetic.

A. H., Natchez, Miss.

ANS.—The area of the end of the ram against which the pressure of the water acts, found by multiplying the square of its diameter by .7854, is $16^2 \times .7854 = 201$ square inches, very nearly. Now, if the pressure of the water under the ram is 4,000 pounds per square inch, the total upward force acting on the ram is $201 \times 4,000 = 804,000$ pounds. A certain part of this force must be used in balancing the weight of the ram and in overcoming the frictional resistances of the ram in the packing; the remainder is available in the form of pressure on the top of the ram. We will assume that 4,000 pounds are required to overcome the weight of the ram and its friction; the total force available at the top then becomes $804,000 - 4,000 = 800,000$ pounds. If this force is



equally distributed over the top of the ram, the pressure on each square inch of the top will be $800,000 \div 31 \times 12 = 800,000 \div 372 = 2,150$ pounds, nearly.

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(158) Have you ever published anything in which different methods of lacing belts are illustrated and described? If not, can you tell me where I can get the information? W. E. E., Atlanta, Ga.

ANS.—The information is given in a small book entitled "Little Belting Catechism," written by Robert Grimshaw, M. E., and published by The Gutta-Percha and Rubber Mfg. Co., New York, N. Y.

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(159) The writer and some friends are interested in a rich farming district in northwestern Pennsylvania—Crawford County, etc.—where the crops now being raised are not very profitable, and we are looking around for something new for the district, and have in mind the beet-sugar industry. If you cannot yourselves give me the following information, perhaps you can refer me to some one that can. (*a*) Is the district mentioned climatically suitable for growing beets? (*b*) What is the smallest plant that could be run on a paying basis, and what would be the approximate cost? (*c*) Is much special knowledge required to operate such a plant, and how long would it be necessary to hire skilled labor, and at what cost? (*d*) Who manufactures machinery for the beet-sugar industry? Any other information will be appreciated. J. O. B., Aspinwall, Pa.

ANS.—(*a*) Yes. (*b*) This depends on a great number of conditions unknown to us, such as price of labor, railroad freights, cost of coal, etc., so that we cannot very well give any figures as to putting the plant on a paying basis. (*c*) Ordinary day laborers may be employed; but you need an engineer to run your steam engine, and an experienced chemist to manage the plant. (*d*) Write to the Oxynard Construction

Co., 32 Nassau Street, New York City, or to E. M. Dyer & Co., New England Building, Cleveland, Ohio. The Department of Agriculture, at Washington, D. C., has published a number of pamphlets on the cultivation of sugar beets, etc., which you can obtain by writing to the Department.

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(160) (*a*) I am running a 155-ton, triple-expansion, Corliss-valve pumping engine. On top of the boilers, to keep the jackets of engine free from water, we have an improved Albany bucket trap. We often have trouble with our engine slowing down, and the valves do not drop right. I think this is all on account of the trap not working. Kindly tell me how I am to know when the trap is working. Should there not be a glass water gauge between the engine and the trap, so that we could keep the water at a certain level all the time—say, 2 feet below the jackets? (*b*) How long does it take a diligent student to complete The International Correspondence Schools course in Steam Engineering?

H. B. S., Broomfield, W. Va.

ANS.—(*a*) It is not very clear from your description how your plant is arranged, but we do not think the trouble you mention is the result of the failure of the trap to work. A glass water gauge, placed as you suggest, would show whether the water is being properly drained from the jackets. A simpler method would be to insert a small test-cock in the pipe, which would serve the same purpose as a boiler gauge-cock. (*b*) Students who have a good knowledge of arithmetic before beginning the course sometimes complete the course within a year. Much depends on the previous amount of studying the student has done and the time he can devote to his studies. Those who attempt to go through the course very rapidly often fail to get the benefit from it that they should.

* *

(161) Without the aid of trigonometry, please solve the following problems: (*a*) A horse is tied to one corner of a rectangular barn 100 feet by 50 feet, at the end of a rope 100 feet long; what area of ground can the horse graze over? (*b*) A horse is tied to the side of a circular shot tower that is 100 feet in diameter, by a rope 100 feet long; what area can it graze over? (*c*) Find three positive integral numbers, the sum of whose squares is a square, and the sum of whose cubes is a cube. F. G. E., Union Bridge, Md.

ANS.—(*a*) The horse can graze over three-quarters of a circle whose radius is 100 feet, and one-quarter of a circle whose radius is 50 feet. It is proved by geometry that the area of a circle is found approximately by multiplying the square of its radius by 3.1416; hence, the area grazed over by the horse is $3.1416\,[\frac{3}{4}(100^2) + \frac{1}{4}(50^2)] = 25{,}525$ square feet. (*b*) It can be proved that the area grazed over is

$$3.1416\left[\frac{100^2}{2} + \frac{100^3}{3 \times 100}\right] = 29{,}041 \text{ square feet.}$$

(*c*) If a, b, and c are any positive integers, then $(a^2 + b^2 - c^2)$, $2ac$, and $2bc$ are three positive integers, the sum of whose squares is a square number, and, by giving different values to a, b, and c, we can get every set of three numbers the sum of whose squares is a square number. Thus, putting $a = 2$, $b = 3$, and $c = 1$, we have $a^2 + b^2 - c^2 = 4 + 9 - 1 = 12$, $2ac = 4$, $2bc = 6$; and $12^2 + 4^2 + 6^2 = 196 = 14^2$. Again, putting $a = 1$, $b = 2$, $c = 2$, we get $a^2 + b^2 - c^2 = 1$, $2ac = 4$, $2bc = 8$; and $1^2 + 4^2 + 8^2 = 81 = 9^2$. In this way you can find as many numbers as you please that satisfy the first condition, and if you continue to find these numbers you may find three that satisfy the second condition also. It is easy to see that $1^3 + 6^3 + 8^3 = 9^3$, and $3^3 + 4^3 + 5^3 = 6^3$; we can find as many of these sets of numbers that satisfy the second condition as we please from the forms $-p^2 + 34pq + 168q^2$, $-6p^2 - 34pq + 28q^2$, and $9p^2 + 70pq + 224q^2$, by giving to p and q any values whatever, subject only to the restriction that p shall lie between $\frac{1}{3}q$ and $-4q$. For example, by making $p = -1$, and $q = +1$, we obtain $-p^2 + 34pq + 168q^2 = 133$, $-6p^2 - 34pq + 28q^2 = 56$, and $9p^2 + 70pq + 224q^2 = 163$. And $133^3 + 56^3 + 163^3 = 190^3$. We do not know whether there is a set of three numbers that fulfils both of the required conditions.

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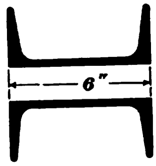
(162) (*a*) Why is alcohol used in hydraulic jacks at all seasons of the year? (*b*) What is the compressive strength of a double channel bar, 6-inch standard steel? (*c*) What is the resistance to buckling of a vertical column 24 feet long, made of the same channels? C. N. C., Newport News, Va.

ANS.—(*a*) There are three reasons for the use of alcohol in hydraulic jacks: It will not rust the parts with which it comes in contact; it will not freeze; it keeps the parts clean. (*b* and *c*) Much confusion exists with regard to what is meant by the term *compressive strength*. The resistance to compression offered by any material varies not only with the nature of the material, but also with the size and shape of the specimen tested. For short specimens, approximating cubes, the compressive, or crushing, strength of the different qualities of steels varies from about 45,000 to 120,000 pounds per square inch. For rolled shapes, such as channel bars, the lower limit should generally be used. Two of the lightest 6-inch standard channels rolled by the Carnegie Steel Company have an aggregate sectional area of 4.75 square inches, and a very short column composed of two such channels would probably have an ultimate resistance to compression of $4.75 \times 45{,}000 = 213{,}750$, or say, 214,000 pounds. The resistance of a column depends not only on the material of which it is composed, but also on the ratio of its length to its least radius of gyration, and on the manner in which its load is applied. The *safe* resistance of a column 24 feet long, composed of two of the lightest 6-inch channels, assuming the column to be flat-ended, with perfect bearings, and its load to be centrally applied, may be taken equal to



$$\frac{4.75 \times 12{,}000}{1 + \frac{1}{48{,}000} \times \frac{288^2}{2.34^2}} = 43{,}300 \text{ pounds.}$$

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(163) (*a*) I want a book on the manufacture of pottery and porcelain. Can you tell me of one? (*b*) I have some samples of clay, kaolin, etc. that I want assayed. Where must I send them? Can you tell me of a good assay house? J. V. R., Hidalgo, Texas.

ANS.—(*a*) "The Chemistry of Pottery," by Carl Langenbeak, for sale by The Technical Supply Co., Scranton, Pa. (*b*) We can recommend you Irving Bachman, Ph. D., Allentown, Pa.; Boston Technical Testing Laboratories, Boston, Mass.; Dickman & Mackenzie, 1224-1228 Rookery Building, Chicago, Ill.

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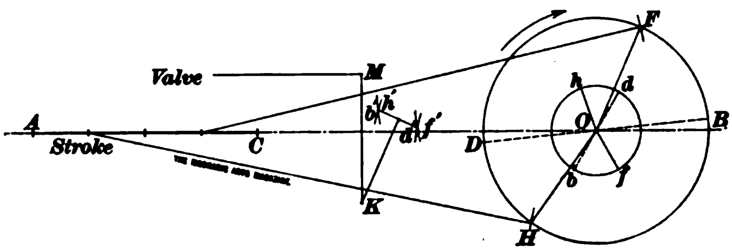
(164) In a steam engine having an ordinary D slide valve, driven by an eccentric on the crank-shaft, how can the lead and the point of cut-off be equalized? In other words, with equal lead, how can the point of cut-off be equalized?

W. H. C., Bar Mills, Me.

ANS.—The point of cut-off can be equalized and equal leads maintained by the use of a rocker so arranged as to neutralize the irregularities of the connecting-rod at the points of cut-off. The method of procedure is as follows: First, determine from the valve diagram the travel, lap, angle of advance, etc., *for one end*, taking account of the connecting-rod. Next, lay out a diagram as in the figure, where $A\ C$ is

the stroke of the crosshead, $DFBH$ is the crankpin circle, and $hdfb$ is the valve circle, with a diameter in this case smaller than the travel of the valve, because of the multiplying effect of the rocker. Cut-off is to take place at, say, $\frac{3}{4}$ stroke. Crank positions corresponding are OF and OH, and we will let crank positions at admission be OD and OB. When a direct-acting rocker is used, the eccentric must be 90° plus the angle of advance ahead of the crank. In the figure, eccentric positions Of and Oh are laid off 90° plus the angle of advance (as found from the diagram) ahead of crank positions OF and OH. In like manner, the eccentric positions Od and Ob are drawn corresponding to the points of admission.



Now, we know that a slide valve is in the same position at both cut-off and admission. Hence, with a radius equal to the length of the eccentric rod, and with admission points and cut-off points d and f as centers, strike arcs d' and f'. The point of their intersection will be the point at which the eccentric-rod pin should be at admission and cut-off on the forward stroke. Connecting these points and erecting a perpendicular half way between them, we have the central position of one arm of the rocker. The other arm KM should be perpendicular to the valve stem at the central position, and the point of intersection K must be chosen so as to make the two lever arms proportional to the throw of the eccentric and the travel of the valve, respectively. By methods similar to the foregoing, the release or compression may be equalized. Whenever, for any purpose, a rocker is used that either increases or diminishes the action of the eccentric on the valve, the valve's travel is to be used instead of the throw of the eccentric for all calculations and constructions connected with the valve diagram, as lap, lead, or cut-off.

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(165) In the early stages of locomotive development, a motion known as the *Dodge wedge motion* was used as a reversing gear; please explain it.
Palestine, Texas.

ANS.—We know of no such motion. Perhaps you allude to the wedge motion introduced in England in 1839 by a man named Dodds, and applied to inside-connected engines. In this motion the two eccentrics, one for each valve, were placed between the two cranks as usual, and in between them was a sliding piece (the clutch box) which moved laterally along the shaft, the latter being squared off where the clutch box worked on it so that the box could not slip around. This clutch box was embraced by a clutch ring, and could be moved along the shaft by the engineer. It carried "wedge" pieces, which moved to and fro inside the eccentrics as the box was slid along this shaft, and, being set at an angle with the latter, caused the eccentrics to move closer to, or farther away from, the shaft center as required, thus altering the throw of eccentrics or reversing the engine entirely. The aim of the inventor seems to have been merely to secure a reversing motion, and not expansive working. An improved form of this motion was used on one of the English roads (the North Stafford Railway) from 1871 to 1880. In this there was only one eccentric for the two gears; there were, of course, two eccentric rods, one for each valve, but they were driven off the same eccentric strap, the left connection being made by means of a bell-crank lever. While this motion was all right theoretically, yet the wedges often stuck and made it difficult or impossible for the engineer to handle his engine. This finally incurred government censure, and lead to its abandonment. Joy's latest valve gear is evidently a development of the one under consideration. It has but very few parts, thereby saving weight, first cost, and upkeep. It does not require reverse lever, reach rod, reverse shaft, links, hangers, or rockers; there is nothing but one eccentric and rod for each valve, the eccentric rod coupling direct to the valve stem guide—a double-eye connection, of course. The reversing is done by fluid pressure. This gear also gives a very fine steam distribution. It has not been used in this country yet; in fact, we have only seen it applied to single engines, so far. It could not readily be adapted to coupled engines.

***

(166) How can I repair a hard-rubber developing tray, the side of which is cracked for about 4 inches? Can I put on a patch of the same material, and how?
G. D. R., Glenville, Ohio.

ANS.—Clean the inside of the cracked surface with benzine and turpentine, and cement a piece of soft rubber (such as elastic bands are made of) over the crack. For cement use the preparation with which bicycle tires are repaired, or dissolve soft rubber in turpentine, to the consistency of molasses.

***

(167) (*a*) What load can be safely carried on a vertical column 15 ft. 4 in. in height, and made of standard 9-inch lap-welded steel pipe, which is 9 inches inside diameter and 9.68 outside diameter? (*b*) Please show how the ultimate strength of such a column, loaded vertically, is obtained.
P. B., Marietta, Ohio.

ANS.—(*a*) The total load P that can be carried safely by the column, if applied centrally upon it, is given by the formula

$$P = \frac{S_c A}{1 + n\left(\frac{l}{k}\right)^2}, \qquad (1)$$

in which l is the length of the column, k is the radius of gyration, and A the area of its cross-section, all in inch units; S_c is the permissible compressive stress per square inch on a short piece of the material, and n is a numerical coefficient having the following values:

For columns having

$$\text{two square ends, } n = \frac{1}{48{,}000};$$

$$\text{one square and one round end, } n = \frac{1}{24{,}000};$$

$$\text{two round ends, } n = \frac{1}{12{,}000}.$$

The area of the cross-section of a hollow cylindrical column is given by the formula

$$A = .7854(D^2 - d^2),$$

in which D is the outer and d the inner diameter. Its radius of gyration is given by the formula

$$k = \tfrac{1}{4}\sqrt{D^2 + d^2}.$$

The value of S_c for the ordinary structural steel may be taken at about 12,000 pounds. For the given column we have

$$A = .7854(9.68^2 - 9^2) = 9.98, \text{ say 10, inches;}$$
$$k^2 = \tfrac{1}{16}(9.68^2 + 9^2) = 10.92;$$
$$l^2 = 184^2 = 33,856.$$

Considering the column as having two square ends, fitting their bearings perfectly, and substituting these values in formula (1), we get

$$P = \frac{12,000 \times 10}{1 + \frac{1}{48,000} \times \frac{33,856}{10.92}} = 112,700 \text{ lb.}$$

(*b*) The ultimate strength of the column may be estimated by substituting for S_c in the numerator of formula (1) a value of from about 42,000 to 48,000 pounds, according to the quality of the steel. Unless the ends of the column are very accurately finished and fitted to their bearings, it is advisable to figure the column as round-ended.

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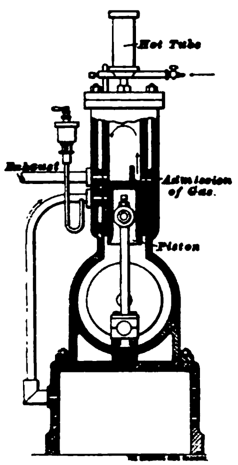
(168) (*a*) In a two-cycle vertical gas engine (see enclosed sketch), explosion every revolution, diameter of cylinder 4 inches, stroke 4 inches, what should be the position of the exhaust port with relation to the lowest position of the top of the piston? (*b*) What should be the position of the admission port? G. L. D., Beardstown, Ill.



ANS.—(*a*) The exhaust port must be slightly above the piston in its lowest position. It must not be too high, else the entering charge will not only drive out the exhaust, but will pass out itself to some extent. On the other hand, if the port is too low, it may be entirely covered by the advancing piston before the charge has had an opportunity to drive out the exhaust entirely. (*b*) The position of the admission port is not of particular consequence. The arrangement shown in the sketch should be satisfactory.

***

(169) (*a*) Explain the simplest method of dividing the circumference of a circle into any number of equal parts without the help of a pair of dividers; I want to use the method for marking out an extra row of holes in a milling-machine dividing head disk. (*b*) Give formula for determining the angle of the teeth of a worm-wheel, so that I may know how far to turn it for the single cutter. H. B., Philadelphia, Pa.

ANS.—(*a*) You will find a table of multipliers that will enable you to set the dividers correctly, so as to divide any circle into from 3 to 80 equal parts, in HOME STUDY MAGAZINE, March, 1898, Answers to Inquiries, No. 65. This will probably help you more than any geometrical method, for the very good reason that, where the number of holes is odd, as 3, 5, 7, 9, 11, 13, etc., no geometrical method will help you; you are bound to use the dividers. (*b*) Divide the lead of the worm by the pitch circumference of the worm; the result is the tangent of the angle of the worm-wheel teeth. From this tangent, find what the angle is by referring to your table of natural trigonometrical functions.

(170) Having received six subscriptions of various amounts in dollars and cents, by what formula can I convert them into English money with accuracy? Give each of the following amounts in English money: $48.45; $60.00; $61.21; $40.00; $58.44; $48.45. What is the total in English pounds, shillings, and pence? "STUCK."

ANS.—The English standard of value is the *pound sterling;* there is no English coin of this denomination, but its value is represented by a gold coin called a *sovereign.* The sovereign contains 113 grains of pure gold, and the American dollar contains 23.22 grains of pure gold. Therefore, a sovereign is worth $\frac{113}{23.22}$ dollars = $4.8665. This is called the par value of a sovereign, or the *par of exchange.* The actual rate of exchange varies from day to day, and can be ascertained only from the reports of the money market or by reference to a banker. Assuming the current rate of exchange to be $4.86 for a pound, we have

		£	*s.*	*d.*
$48.45 =	$£\frac{48.45}{4.86}$ =	9	19	$4\frac{1}{2}$
$60.00 =	$£\frac{60.00}{4.86}$ =	12	6	$11\frac{1}{4}$
$61.21 =	$£\frac{61.21}{4.86}$ =	12	11	11
$40.00 =	$£\frac{40.00}{4.86}$ =	8	4	$7\frac{1}{2}$
$58.44 =	$£\frac{58.44}{4.86}$ =	12	0	6
$48.45 =	$£\frac{48.45}{4.86}$ =	9	19	$4\frac{1}{2}$
$316.55 =	$£\frac{316.55}{4.86}$ =	65	2	$8\frac{1}{4}$

***

(171) What is the formula for finding the horsepower of a turbine waterwheel? L. L. P., St. Louis, Mo.

ANS.—There is no general formula for calculating the horsepower of a turbine waterwheel that is based on the dimensions of the wheel; the horsepower of any water motor is, however, given by the formula

$$\text{H. P.} = C\frac{62.5\,Q\,h}{550} = .1136\,C\,Q\,h,$$

in which Q = quantity of water used in cubic feet per second;
h = available head or fall in feet;
C = a coefficient that represents the efficiency of the motor.

A turbine wheel correctly proportioned for its work should give an efficiency of 75 per cent.; using this value, we have

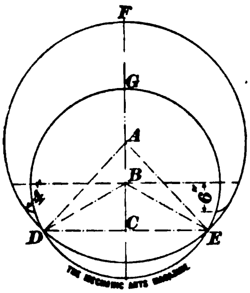
$$\text{H. P.} = .1136 \times .75 \times Q\,h = .0852\,Q\,h.$$

***

(172) (*a*) Give the names of a few makers of pumps and engines suitable for pumping large quantities of water from excavations. (*b*) Where can I obtain reliable information regarding steam boilers suitable for water-works plants? A. B. C., New York City.

ANS.—(*a*) The Lawrence Machine Co., Lawrence, Mass.; Baldwinsville Centrifugal Pump Works, 718–725 W. Fayette St., Syracuse, N. Y.; Rumsey & Co., Seneca Falls, N. Y.; Joseph Edwards & Co., 414 Water St., New York City; The Pulsometer Steam Pump Co., 135 Greenwich St., New York City. (*b*) Any good type of boiler is suitable for water-works plants. The best boiler for a given plant will depend largely on the location of the plant and the character of the feedwater. If a moderately pure feedwater is available, water-tube boilers will probably give satisfactory results; if the water contains large quantities of mud or of scale-forming impurities, return-tubular boilers are to be recommended.

(173) I have a steam boiler 40 inches in diameter. Upon this I wish to put a saddle tank, the end of which must have an area of 850 square inches; the lower part of the tank is to extend 6 inches below the center of the boiler, as indicated on enclosed sketch. Give formula for determining the distance of center A above B. The outer diameter of the tank may be struck to an even radius, as shown.



M. S. T., Lima, Ohio.

ANS.—With these data the problem admits of more than one solution; for the data give only four equations from which to determine five unknown quantities. Let the two circles intersect in the points D and E. Then the area of the end of the saddle is very nearly equal to the area of the lune $DGEF$.

Let s = area of lune $DGEF$;
$r = BD$ = radius of boiler;
$x = AD$ = radius of saddle;
$y = BC$;
$z = AB$;
m = number of degrees in the angle DBE;
n = number of degrees in the angle DAE;
π = ratio of a circumference to its diameter = 3.1416, nearly.

Then the area s is given by the formula

$$s = \frac{x^2}{2}\left(2\pi - \frac{n\pi}{180} + \sin n^\circ\right) - \frac{r^2}{2}\left(2\pi - \frac{m\pi}{180} + \sin n^\circ\right) \quad (1)$$

$$x \sin\frac{n^\circ}{2} = r \sin\frac{m^\circ}{2} \quad (2)$$

$$y = r\cos\frac{m^\circ}{2} \quad (3)$$

$$y + z = x\cos\frac{n^\circ}{2} \quad (4)$$

In these equations we are given $r = 20$, and we may take s = area of end of saddle = 850; then, we have five unknown quantities, m, n, x, y, and z.

In order to get a solution that will probably suit your problem, we assume

$$y = 10.$$

Then, equation (3) gives $m = 120$.
By trial we found $m = 86$ (nearly),
which gave $x = 25.396$,
and $z = 8.574$.
That is, $AD = 25.396''$, $AB = 8.574''$.

This value of AD and AB gives the area of the lune $DGEF$ as 853 square inches, and of course the actual area of the saddle is a little less than the area of the lune.

***

(174) Is it possible to throw a baseball in such a manner that the ball describes a curve in the air, other than the curve due to the effect of gravity? It is claimed by some that twirling the ball in different ways makes the ball curve away from the direction in which it was thrown. A. B. A., Richmond, Va.

ANS.—We are not expert pitchers, but we know that it is not only *possible* to make the ball curve, but that for a pitcher to be successful he *must* be able to control the ball in this manner. The curving is directly due to the fact that the resistance of the atmosphere is greater against the side of the ball that, in consequence of the rotation of the ball on its axis, is moving in the same general direction as the ball itself is traveling. This rotatary effect is considerably increased by the existence of slightly raised seams on the surface of the ball. There is nothing wonderful about the curving of a baseball; indeed, there has never yet been discovered a form of projectile that does *not* curve more or less from the direction in which it is thrown. In a perfect vacuum, a body, no matter what the shape, would move in the direction of projection, the only curve being that due to gravity; but it is not possible, practically, to make a body that, when moving through the atmosphere, will not curve to some extent either one way or another; this is because it is not possible to make a perfectly symmetrical body, or one that is of exactly the same smoothness all over, and because the motion of the air around the body is irregular and beyond control.

***

(175) I have a small upright steam boiler of the following dimensions: Outside diameter, 24 inches; thickness of shell, ¼ inch; height from grate to top of flues, 47 inches; number of flues, 31; diameter of flues, 2 inches; length of flues from crown sheet to top of boiler, 29 inches; height of firebox over grate bars, 18 inches; width, or diameter, of firebox, 20 inches. The firebox has a 2-inch water space around it; the flues are not submerged. (*a*) What is the horsepower of this boiler? (*b*) What horsepower engine with what size cylinder can it run to advantage? (*c*) Where can I get unfinished castings and parts for such an engine? (*d*) For heating private residences, what system is considered the most economical as regards fuel consumption, when burning wood—steam, hot air, or hot water? And which of the three is the least expensive to install? (*e*) Can you recommend a practical book in which the erection of heating systems is explained?

S. G., Red Lake Falls, Minn.

ANS.—(*a*) Four horsepower. (*b*) Four horsepower; $4'' \times 6''$ cylinder. (*c*) We do not know of any firm making a business of selling unfinished engine parts except such as are suitable for models only. Perhaps if you write to makers of small engines, of which you will find advertisements in trade papers, they may accommodate you. (*d*) We should consider the hot-water heating system the most economical when burning wood, although the hot-air system is the least expensive one to install for small residences. (*e*) "American Hot-Water and Steam-Heating Practice"; "Carpenter's Heating and Ventilating of Buildings," \$3.00; Baldwin's "Steam Heating," \$2.50. These books can be obtained from The Technical Supply Co., Scranton, Pa.

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(176) (*a*) By what process may aluminum castings be polished and made to retain their brilliancy? (*b*) Will the same process do for copper castings? If not, how must they be treated?

L. L., Paterson, N. J.

ANS.—The processes are much the same for each metal. There are, broadly speaking, three stages in the operation: 1. *Grinding*, or *emerying*. Buff wheels covered with leather are used, the abrading material being coarse emery or pumice. 2. *Rubbing down*. Wheels made up of linen or woolen rags are used, together with flour emery and oil. 3. *Polishing*, or *coloring*. Soft rags are now employed, together with tripoli, rouge, rotten stone, crocus, etc. When the articles are old ones that have become tarnished, they may be brightened up by putting them in a bath of potash lye, not too strong; or an emulsion of equal parts of rum and olive oil, well shaken up, may be used. Copper articles may be polished by using a mixture of rotten stone (well powdered and sifted), soft soap, and oil of turpentine. These ingredients are to be made into a stiff putty, then a small quantity mixed with water and applied with a dry rag or chamois leather.

(177) (*a*) How do patternmakers make the layouts for spur and bevel gears? (*b*) Given two wooden patterns of bevel gears, how would you proceed to make drawings of them? (*c*) What do you consider the best work on gear-tooth layouts? (*d*) What is the best general treatise on mechanical drawing?
V. G. M., Cleveland, Ohio.

ANS.—(*a*) For an excellent method of laying out gear-tooth profiles, see THE MECHANIC ARTS MAGAZINE, April, 1899, page 127. With slight variation the same method can be used for bevel gears, but for the general layout of bevel gear-teeth, see HOME STUDY MAGAZINE, September, 1897. (*b*) Take as accurate measurements as possible, and from them make a drawing. You must first understand how to lay out a bevel gear. (*c*) George B. Grant has written what is probably the best book on gearing; his address is Lexington, Mass. (*d*) The mechanical-drawing instruction paper of THE INTERNATIONAL CORRESPONDENCE SCHOOLS, Scranton, Pa.

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(178) Please advise me as to the strength and durability of a brick wall built and bonded with wire anchors, as shown in enclosed sketch (Fig. 1). F. R. S., Unionville, Mass.

ANS. — The wire anchors would be better and cheaper if they were made so as to be square across the opening, as in Fig. 2. The wires in the position shown in Fig. 1 give the walls a chance to buckle, by reason of the wires becoming straight under stress.

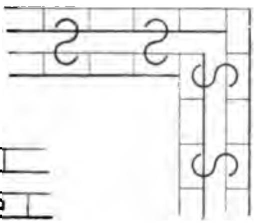

FIG. 1.

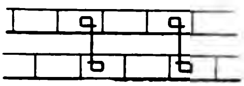

FIG. 2.

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(179) Kindly explain as fully as possible the action of a balance ring, cross-connecting the commutator of a direct-connected generator.
E. N. S., Wilkinsburg, Pa.

ANS.—A copper cross-connector is used between the brushes of like sign in the case of loop-wound armatures. Each circuit through the armature generates current and requires connection to the external circuit. This could be obtained by running cables from all the brush-holder studs, but it is simpler to make one cable connection for each positive and negative main lead and cross-connect the remaining brushes.

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(180) (*a*) What is the declination of the magnetic compass needle at Boston, Mass.? (*b*) Is the declination there increasing or decreasing since 1894? (*c*) How many degrees does the deviation of the needle change each year? (*d*) What is the inscription on the Arch of Titus, illustrated in the May number of THE MECHANIC ARTS MAGAZINE? What is the meaning of the words? Who was emperor of Rome at the time the arch was built? L. C. P., Fort Fairfield, Me.

ANS.—(*a*) About 12° 23′ west declination. (*b*) Increasing. (*c*) The yearly, or secular, change in the declination of the needle is not the same in all localities, and is not constant for a given locality. The variation of the yearly change for a given locality, however, is very slow and gradual. The average yearly change for different localities in the United States is about (somewhat less than) four minutes. (*d*) Owing to the peculiarities of the grammar of the ancient Latin language, a literal translation of this inscription cannot be easily rendered. The words mean "Senate, People, and Romans, to the divine Titus, son of the divine Vespasian. Vespasian August." In good English, the sentence may be rendered as follows: "Senate and People of Rome, to the divine Titus, son of the divine Vespasian, erected during the reign of the noble Vespasian."

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(181) (*a*) In making the exposuremeter described in HOME STUDY MAGAZINE, January, 1899, what speed plate should be used for determining the tints for *a* and *b* in Fig. 3? (*b*) To which class would the Blake dry plate (25 *x*) belong, in the table of plates given? (*c*) To which class, the Stanley (Sensitometer 50)? F. G. C., Boston, Mass.

ANS.—(*a*) Any speed of plate may be used, but preferably one of those in column 2½ or 4 of the table. Calculations may then be made for other brands according to the table. (*b*) The Blake 25 *x* dry plate was not regularly tested with the other brands mentioned, but according to its sensitomer mark would probably be classed in column 1½ of table. (*c*) The Stanley 50 belongs in column 1.

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(182) Kindly give formula for solder for soldering brass to aluminum. W. V. L., Bristol, Pa.

ANS.—Novel's solder for aluminum bronze is claimed to be suitable for joining aluminum to copper, zinc, brass, iron, or nickel. The formula is:

Tin	900 parts
Copper	100 parts
Bismuth	2 to 3 parts

It is asserted that surfaces of aluminum may be soldered to each other and to other metallic surfaces by using silver chloride as a flux in conjunction with ordinary solder. See Scientific American Cyclopedia of Receipts, page 702.

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(183) I am wiring a house for incandescent lights; the house has eight rooms; I am going to use the 110-volt alternating current from the city supply main. (*a*) What size wire must I use? (*b*) Shall I use the same size throughout the eight rooms? (*c*) I intend to put in a step-down transformer and a meter; where should they be placed?
C. H. B., Ohio.

ANS.—(*a* and *b*) Use No. 12 B. & S. for your mains, and No. 14 B. & S. for branch circuits. (*c*) Place the transformer outside of the building, on the side of the house or on the pole. Place the meter inside, where the wires enter the building.

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(184) I have a ⅛-horsepower series-wound fan motor that I built myself. It is run by six cells of bichromate plunge battery. The field magnets are wound with three layers of No. 10 double cotton-covered magnet wire, and the armature has eight coils wound with No. 16 double cotton-covered magnet wire, there being one layer of seven turns to each coil, and the last four coils laying over the first four, thus making two layers of wire in each groove. (*a*) What size wire and how many turns shall I use to rewind the motor so that it will run in series with a 270-volt incandescent lamp on a 270-volt direct-current circuit? (*b*) What size and how many turns to connect it direct? (*c*) Would I obtain better results if I used the return current from a number of lamps connected in parallel? (*d*) I have a 10-horsepower shunt-wound motor that has an armature speed of 1,700 revolutions per minute; it is wound with No. 8 double cotton-covered wire; what would be the speed if rewound with No. 15 double cotton-covered wire? E. B. R., Delcarbo, Ind.

ANS.—(*a*) You can run the motor by connecting it in series with a suitable number of lamps in parallel. (*b*) It would be necessary to use No. 29 or 30 wire to run the motor directly from the circuit, but even this would not be satisfactory, because there are not a sufficient number of commutator segments for such a high voltage, and you would have destructive sparking. (*c*) Yes. (*d*) If the same field were used, the speed would be about one-fifth.

(185) (*a*) What is the value of 500 wrought-iron rods, 9 feet long and 1¼ inches in diameter, at the rate of $63.33 a ton of 2,000 pounds? (*b*) Eliminate θ from

$$x \cos\theta + y \sin\theta = 1. \qquad (1)$$
$$x' \cos\theta + y' \sin\theta = 1. \qquad (2)$$

H. E. B., N. Windham, Conn.

ANS.—(*a*) The number of cubic inches of iron in the rods is $500 \times 108 \times 3.1416 \times (.625^2)$; and, if we assume that wrought iron weighs 480 pounds per cubic foot, which is equivalent to $\frac{480}{1728}$ pound per cubic inch, we get the number of pounds of iron to be $500 \times 108 \times 3.1416 \times (.625^2) \times \frac{480}{1728}$. But the price is $\frac{63.33}{2,000}$ dollars per pound; therefore, the value of the iron rods is

$$500 \times 108 \times 3.1416 \times (.625^2) \times \frac{480}{1,728} \times \frac{\$63.33}{2,000} = \$582.89.$$

(*b*) Multiplying (1) by y',

$$x y' \cos\theta + y y' \sin\theta = y'. \qquad (3)$$

Multiplying (2) by y,

$$x' y \cos\theta + y y' \sin\theta = y. \qquad (4)$$

Subtracting (4) from (3),

$$(x y' - x' y) \cos\theta = y' - y. \qquad (5)$$

Similarly, $(x y' - x' y) \sin\theta = x - x'. \qquad (6)$

Squaring both members of (5),

$$(x y' - x' y)^2 \cos^2\theta = (y' - y)^2. \qquad (7)$$

Squaring both members of (6),

$$(x y' - x' y) \sin^2\theta = (x - x')^2. \qquad (8)$$

Adding (8) to (7),

$$(x y' - x' y)^2 [\cos^2\theta + \sin^2\theta] = (y' - y)^2 + (x - x')^2.$$

Therefore,

$$(x y' - x' y)^2 = (y - y')^2 + (x - x')^2.$$

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(186) (*a*) Did you ever know of a case where the side walls of a boiler setting were made with a flue—one on each side—running back and forth horizontally and lengthwise, and through which the air for the fire had to go on its way to the fire, and thus be heated and also improve the draft? Of course these flues would be made of piping. (*b*) Do you think such an arrangement would be any good?

W. T. C., New Castle.

ANS.—(*a* and *b*) We are not acquainted with any such arrangement, and do not care to pass an opinion on its merits.

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(187) (*a*) What should be the dimensions of an oak axle to carry 2,500 pounds, the length between wheels being 5 feet? What, if the axle is made of steel? (*b*) Do you know of any books on well drilling, or any magazines published for well drillers?

J. P. L., Steinbach, Man., Can.

ANS.—(*a*) The axle is subjected to the greatest bending moment when its total load is concentrated upon a section midway between its wheels. The bending moment M_b is then given by the formula

$$M_b = \frac{Wl}{4},$$

in which W is the total load, and l is the length of the axle between supports. Assuming this extreme condition in the present case and applying this formula, we shall have for the bending moment,

$$M_b = \frac{2,500 \times 5 \times 12}{4} = 37,500 \text{ inch-pounds.}$$

For a beam of rectangular cross-section, the moment of resistance M_r is given by the formula

$$M_r = \frac{S b d^2}{6},$$

in which b = width of cross-section;
d = depth of cross-section; and
S = permissible value of the extreme fiber stress.

For white oak, S may have a value of 1,000 pounds per square inch. Using this value for S, assuming $b = \frac{3}{4} d$, and writing the moment of resistance equal to the bending moment, we have

$$\frac{1,000 \times \frac{3}{4} d^3}{6} = 37,500;$$
$$d = \sqrt[3]{300} = 6.69;$$
$$b = \tfrac{3}{4} \times 6.69 = 5.$$

A white-oak axle 5 in. × 6¾ in. will therefore give the required strength. For rolled steel of the quality commonly known as *medium steel*, the value of S may be taken at 15,000 pounds per square inch. Using this value, assuming the cross-section of the axle to be square, so that $b = d$, and writing M_r equal to M_b, we have

$$\frac{15,000 d^3}{6} = 37,500;$$
$$d = \sqrt[3]{15} = 2.47.$$

Consequently, an axle 2½ inches square, composed of medium steel, will give the required strength. (*b*) We know of no book on well drilling nor magazine published for well drillers. You will find considerable information on this subject in a book entitled "Wells and Well Sinking," by Swindell and Burnell, price 50 cents; for sale by The Technical Supply Co., Scranton, Pa.; also in THE MECHANIC ARTS MAGAZINE, April, 1899, article entitled "Water Supply and Artesian Wells."

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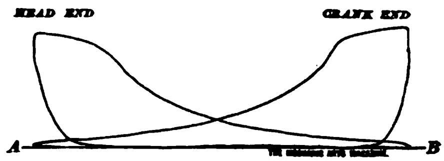
(188) Will you kindly work out and explain the enclosed diagram? The engine is a simple Fahling load, electric-lighting plant of 450 amperes, and cash



A-B LINE OF ATMOSPHERIC PRESSURE

railway requiring 7 horsepower; revolutions per minute, 100; piston diameter, 18 inches; piston stroke, 36 inches; piston speed, 600 feet per second; piston area, 254.5 square inches; engine constant, 4.62; scale of spring, 50; boiler pressure, 70 pounds gauge; exhaust into heating system of large 6-story building. Also give your criticisms of the engine.

J. D., Washington, D. C.

ANS.—By measurement with a planimeter, the area of the head-end diagram is 1.76 sq. in. and that of the crank-end diagram is 1.92 sq. in. The length of the diagram is 4.2 inches. Hence, the M. E. P. for the head-end is $\frac{1.76 \times 50}{4.2} = 20.95$ lb. per sq. in., and that for the crank-end is $\frac{1.92 \times 50}{4.2} = 22.86$ lb. per sq. in. Using your engine constant (4.62), the horsepower developed in the head-end is $20.95 \times 4.62 = 96.79$, and that in the crank-end is $22.86 \times 4.62 = 105.62$. The total horsepower is, therefore, $96.79 + 105.62 = 202.41$. We see nothing about the diagrams to demand special explanation or criticism, with the possible exception that the work is not quite equalized between the head-end and the crank-end.

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(189) (*a*) What is the formula to find the number of hours in the year that the sun is below the horizon? (*b*) Is the total number of hours that the sun is below the horizon the same for every year? (*c*) With a clear sky, for how many nights in a lunar month is the light from the moon equal to .03 candlepower at 1 foot?

SOMERSET, Winnipeg.

ANS.—Too much time and labor would be required to investigate and answer your questions fully. Would advise you to write to the editor of "The Astronomical Journal," Cambridge, Mass.

THE POWER OF HABIT.

FEW things can be more humiliating than the consciousness of possessing a college diploma that means nothing in practical life; of having passed one's examinations in a parrot-like way; of being looked upon as an educated man, and yet as having no ability; or of being so unreserved as to tell all one knows. Nobody has confidence in the man without reserve, and he cannot, of course, believe in himself. A single speech exhausts him; the slightest emergency pumps him dry; he is in constant fear lest the slightest mistake may uncover his shallowness and expose his emptiness.

Not least among our forces in reserve are those which come from that "facility and inclination, acquired by repetition," which we call habit.

Habit is defined as the tendency or inclination toward an action or condition, which, by repetition, has become easy, spontaneous, or even unconscious. Thought itself is governed by habit.

How is thought governed by habit? Every man has two kinds of opinions, one kind consisting of logical conclusions that are the result of thought, while the other kind consists of opinions that are merely the result of habit. The majority of our opinions are of this last character. We, ourselves, call them our "views"—other people call them our "prejudices." Most of what we call "thinking" on every-day occurrences of life is little more than a mechanical adjustment of our minds to our environment. There is a strong tendency in us all to accept what seems inevitable as right. This applies to most of our ideas about the conventionalities of life, but it also applies to more important matters. Fifty years ago everybody in the South and almost everybody in the North defended slavery. The conviction was not a logical conclusion—it was a habit. Slavery had always existed, and our thinking was adjusted to it; it therefore seemed a part of the Divine plan. Our thinking is at present adjusted to the wide existence of poverty in the world. Some people think that this is not an intelligent conviction, but a habit of thought which we may get rid of some day.

If you wish to change a man's opinion on any subject, the first thing to do is to find out whether that particular opinion is a logical conclusion with him or an opinion formed from habit. If it is a logical conclusion, you can change it by argument; but if it is a mere habit, argument will only irritate him and make him stubborn. You must give him a chance to outgrow it. As we grow older we form many such habits, which constitute a kind of "mechanism of thought." After that, when a new proposition is presented, the first question is not "Is it true?" but, "Does it accord with my views?" If it fits into our mechanism of thinking, we accept it; if it does not, we reject it. In this way most of us crystallize at about forty and fossilize at about sixty years of age. Great minds, however, remain plastic until extreme old age. Gladstones and Beechers never fossilize.

Any occupation is, in general, however, easiest to him that has familiarized himself with its processes by repeated practice, and he that has become familiar with those processes is most likely to succeed therein. As men acquire greater and greater skill in the various trades or professions, it becomes more and more difficult for one to do many kinds of work in a satisfactory manner, in competition with others.

Jacks of all trades are gradually becoming scarcer as we advance in civilization. We must concentrate our energies to definite purposes in proportion as we wish to excel. "I have but one lamp by which my feet are guided," said Patrick Henry, "and that is the lamp of experience."

It is experience that teaches individuality. No man is genuine who is forever trying to pattern his life after the lives of other people. But individuality is by no means the same as genuineness. Individuality may be associated with the most extreme and ridiculous eccentricity. Genuineness is always wholesome, balanced, touched by dignity and strengthened by the lessons of salutary experience. That character is genuine which is built by nature, improved by habit, and rests upon the unseverable foundations of independence and courage.

COST IS THE LAW OF EDUCATION.

WORK done is always energy expended. All the operations of nature, from the growth of a grass blade to the burning of a star, are carried on at the expense of energy. On the farm, the products of the soil cost much. Nature herself will not fill the barn. Virtue must go out of human brains and hands, and mix with her elements, and then the hills will wave with wheat and the valleys rustle with corn. The chief difference between the savage and the civilized man is that the savage puts nothing into nature and gets out only what he can pick up; and civilized man puts virtue—his own power and skill—into nature and gets out an abundance. In the factory, the piece of furniture or a web of cloth, costs the combined skill and toil of many hands. In the artist's studio, the picture costs intense thought and patient effort.

Commerce is the exchange of things that have cost something. A thing may be highly useful, but if it has cost nothing in human skill and toil, it has no market value. Air is useful, but no one can sell it because no one has put any virtue in it. Much of the dishonesty and crime in the world grows out of the effort to escape this law of cost. Theft, cheating, fraud, speculation, are means by which men try to get money without letting any virtue go out of them. The standing problem with many is how to turn one dollar into five without perspiration.

Cost is the law of education. The mind grows only by exercise. Reason, memory, imagination, and will must be aroused and concentrated on the objects of thought; and when virtue has gone out of the mind, the hidden language will grow luminous, the complex problem will be solved. Any system that lets the student slip through without cost, is a method of education that does not educate.

DUST ON THE KEY.

SOMETHING was wrong with a great organ. One of the keys refused to sound. Strike as hard as he might, no response came to the ear of the organist. In the grand symphony all was perfect except that one note; and the break caused by that one missing note was enough to mar the beauty of the entire production.

The organist sent for a skilled workman from the manufactory. Carefully he opened the wonderful instrument until he had reached the silent reed. Drawing it from its place, he held it up to the light. No defect was to be seen in the metallic plate. The tongue was in its place in the slot prepared for it. But as the light fell through the opening occupied by the vibrating tongue, the keen eye of the mechanic detected a single atom of dust. With an instrument sharply pointed like a pencil he pushed the atom aside, wiped the reed gently, pushed it into place, again tried the key, and once more the note responded clear as the tones of a flute. The speck of dust had caused all the trouble. It was not necessary to drive a wedge between the tongue of the reed and the plate that held it, nor to strike it heavily with a hammer. Just that little mote was sufficient to spoil the music.

If the lives of people that never amount to much, or that fail totally, are subjected to analysis, we find that their inefficiency is usually due to some little weakness, some lack of knowledge, some absence of skill that might easily enough, perhaps, have been remedied. One boy, for instance, fails to get a position, or to rise to a higher one, because of uncouthness—utter lack of courtesy or politeness. Gruff and disagreeable in his manners, no one likes him, and he never gets on. Unconscious of the cause of his failure, he becomes, as he grows older, sour and pessimistic. A hot temper, or an entire lack of self-control, holds another young man in some subordinate position. Still another falls short because of shiftlessness, laziness, and want of energy. He may be kind-hearted and honest, but lacks push and pluck. Another, again, fails of advancement because of a morbid disposition, which prohibits his harmonizing with people for whom he works, or with whom he associates—he is glum, morose, absent-minded. Differing from all these, is another young man, bright, cheerful, kind-hearted, good-natured, polite, whom everybody likes; but lacking purpose, and having no definite aim, he is in a condition of stable equilibrium, not inclined to move in one direction more than another. All these, some one may say, are little things. Yes, merely "dust on the key." But success hangs on just such trifles. The young man that would succeed must always guard his weak point. The chain's greatest strength lies in its weakest link. Young men are proud of their strong links, but cover up, hide, and are ashamed of their weak ones. The chain breaks, however, at its weakest link, and then they are surprised because they have failed.

JAMES J. HILL.

FROM DECK HAND TO RAILROAD PRESIDENT AND OWNER.

STEADFASTNESS of aim and unflagging industry in the attainment of his purposes have been distinguishing marks in the life of James J. Hill. He has made himself thorough master in principle and practice, in general and in detail, of every position, from the humblest to the highest that he has ever filled. This is the secret of his success. The unsettled and unindustrious man who, on entering the duties of a position, makes up his mind that its duties are not worth knowing well, never succeeds. He is always looking for something better, but does not obtain it for the reason that he neglects the only sure means of obtaining promotion. The man who thoroughly masters all the details of duty in the humblest position to which he may be appointed is the man certain to come to the front. Such a man never neglects opportunities of self-improvement. His hours may be long, his duties onerous, but he will find a few moments at least every day for reading and study. He has his favorite papers and his favorite books. He reads carefully and thoroughly, and thus lays up valuable stores of information that some time in life will stand him in good stead.

JAMES J. HILL.

Mr. Hill began at an early age to carve out a place of his own in life. Circumstances compelled an humble beginning, but he resolved to go higher; and realizing that knowledge and study are the secrets of advancement, determined to learn all he could.

In his early days, when working as a deck hand on the Mississippi River, he found time and means to spare for books. He made himself at that time familiar with the history of the country in general, and of the Northwest in particular; and, after learning all he could of the United States, did not rest satisfied till he had mastered all the political and geographical peculiarities of foreign countries. To acquire books in early life and on scant pay, he saved, and has ever since saved. Even when his wages were but $10 a week, he saved. Study leads to habits of thrift and economy. The truly studious man is ever thrifty, for extravagance and profligacy are incompatible with habits of study. Thrift is not in any way connected with avarice, usury, greed, or selfishness. It is, in fact, the very reverse of these objectionable qualities. Thrift means independence to secure prosperity. Thrift is under the influence of reason and forethought, and never works by chances or fits. Hence, the thrifty man is usually a man of study and reflection. Mr. Hill has ever been such a man.

As a result of life-long study, Mr. Hill knows all about railroading, from the surveying of a line, its grading, track laying, locomotive and car building, and operating, to its financiering, and there is not one of his army of employes to whom he cannot tell more than the man himself knows about his own particular branch of the business.

To earnest, persevering study, and the habits of life demanded by such study, Mr. Hill owes his success of today. He is now president and owner of the Great Northern Railway, extending from Seattle, Wash., to St. Paul and Duluth, Minn., besides controlling other great interests.

He is one of the most democratic of men; there is no one too humble for him to speak to. In spite of advanced years, he is as indomitable in spirit as when he first started out in the world to make a way for himself. To him idle moments are still utter strangers; his continuous success in life is a monumental tribute to the genius of work and the habit of well-ordered study.

WONDERFUL ATTAINMENTS OF JAMES WATT.

MR. JAMES WATT, the great improver of the steam engine, died on the 25th of August, 1819, at his home in Heathfield, near Birmingham, in the 84th year of his age.

His name needs no commemoration of ours, for he that bore it survived to see it crowned with undisputed and unenvied honors; many generations will probably pass away before it shall have gathered "all its fame." Mr. Watt was the great improver of the steam engine; but, in truth, as to all that is admirable in its structure, or vast in its utility, he should rather be described as its inventor. It was by his inventions that its action was so regulated as to make it capable of being applied to the finest and most delicate manufactures, and its power so increased as to set weight and solidity at defiance. By his admirable contrivance, it has become a thing stupendous alike for its force and its flexibility—for the prodigious power that it can exert, and the ease, and precision, and ductility with which that power can be varied, distributed, and applied. The trunk of an elephant, that can pick up a pin or rend an oak, is as nothing to it. It can engrave a seal, and crush masses of obdurate metal before it—draw out, without breaking, a thread as fine as gossamer, and lift a ship of war in the air. It can embroider muslin and forge anchors—cut steel into ribbons, and impel loaded vessels against the fury of the winds and waves.

It would be difficult to estimate the value of the benefits that this has conferred upon this country. There is no branch of industry that has not been indebted to it; and, in all the most material, it has not only widened most magnificently the field of its exertions, but multiplied a thousandfold the amount of its productions. It was the improved steam engine, in short, that exalted and sustained, through the late contest, the political greatness of our land. It has increased indefinitely the mass of human comforts and enjoyments; and rendered cheap and accessible, all over the world, the materials of wealth and prosperity. It has armed the feeble hand of man with a power to which no limits can be assigned; completed the dominion of mind over the most refractory qualities of matter, and laid a sure foundation for all those future miracles of mechanical power that are to aid and reward the labors of after generations. It is to the genius of one man, too, that all this is mainly owing. And certainly no man ever bestowed such a gift on his kind. The blessing is not only universal but unbounded; and the fabled inventors of the plow and the loom, who were deified by the erring gratitude of their rude contemporaries, conferred less important benefits on mankind than the inventor of our present steam engine.

HOW TO SUCCEED IN STUDY.

SUCCESSFUL study rests on the basic ground of a desire for improvement, of which a great writer has aptly formulated the maxim: "The desire of improvement discovers a liberal mind, and is connected with many accomplishments and many virtues."

The first essential requisite in all educational work is to know how to study. But to know how to study, we must first know what it is we have to study. Each man's purpose in life indicates *what* it is he has to study, while the earnestness of his purpose dictates *how* he is to study it. He must, however, in general, bring to all studies method, order, discipline, based on thoroughness of purpose, to become master of fundamental principles and essential details.

The man that attempts to study without method is like the sloth, of whom a very wise man wrote: "I went by the field of the slothful, and by the vineyard of the man void of understanding: and lo! it was all grown over with thorns: nettles had covered its face; and its stone wall was broken down. Then I saw and considered it well: I looked upon it, and received *instruction.*"

Failure in study is, as in other things, often due to the lack of order and absence of thoroughness. Does not the whole experience of our lives teach the value of the present moment and the importance of its honest employment?

> Be wise today: 'tis madness to defer:
> Next day the fatal precedent will plead—
> Thus on, till wisdom is pushed out of life.
> Procrastination is the thief of time.
> Year after year it steals, till all are fled;
> And, to the mercies of a moment leaves
> The vast concerns of an eternal scene.

Summed up, much that can be advised as to method in study may be stated thus:

Be thorough. When studying, limit yourself to one subject at a time. When, for instance, you reach the subject of pneumatics, study pneumatics, and study until you master it before you begin to work on

the next subject. Unless you thoroughly understand a subject before you leave it, you will not derive the greatest benefit from its study. Moreover, the standard you attain in each subject depends on the thoroughness of the preceding work. Be sure you understand every principle.

Be accurate. If you are careless with one subject the next will be more difficult. By doing the work of each subject carefully and thoroughly before taking up the next higher, your work becomes easier and more interesting as you advance. An examination will show the character of your previous work. If it has been done carelessly you should do all or part of your work over again, before you leave it.

Be careful and neat. Anything worth doing at all is worth doing well. Make your work look so neat that you will wish to preserve it and will take pride in showing it to your friends. Do everything as well as your ability permits. It is the careful student that makes the successful man.

Be self-reliant. You must not form the habit of relying upon others. Rely upon yourself. Men of self-reliance are the men that conquer great difficulties. Do not ask how long it will take you to finish an education; it depends upon yourself. As you advance you will gain confidence and rapidly acquire ability to overcome obstacles. Take up each study with the confidence that you can and will master it. Courage is half the battle won, and perseverance will win the other half. Face the hard lines in your lesson with determination. Think about them and reason them out during the day, while you are at work. It is a common experience that in later years we value highly that which we have obtained with difficulty.

RESERVE FORCE.

"IT IS marvelous, Monsieur le President," said the Paris correspondent of the London "Times," some years ago, to Thiers, "how you deliver long, improvised speeches about which you have not had time to reflect." "You are not paying me a compliment," replied the President of the French Republic, "it is criminal in a statesman to improvise speeches on public affairs. The speeches you call improvised—why, for fifty years I have been rising at 5 A. M. to prepare them!"

A man's work shows whether he has expended the last ounce of his strength upon any achievement, or has a reserve back of him. His conversation sooner or later betrays an empty or a full reservoir. Every victory won, every obstacle overcome, every passion controlled, adds a new strand to our reserve cable. Every defeat, every loss of self-control, breaks or strains a strand, and weakens the cable.

Do not mistake acquirement, or mere knowledge, for power. Like food, these things must be digested and assimilated to become life or force. Learning is not wisdom; knowledge is not necessarily vital energy. The student that has crammed through a school or a college course and has made himself merely a receptacle for the teacher's thoughts and ideas, is not educated. He has not gained much; he is a reservoir, not a fountain. One retains, the other gives forth. Unless his knowledge is converted into wisdom, into faculty, it will become stagnant like still water. His knowledge must be drawn from the reservoir of memory, be worked over by the practical faculties, and become vitalized, before it can become a real power in the world.

MODERATION.

AMUSEMENT in moderation is wholesome, and to be commended; but amusement in excess vitiates the whole nature, and is a thing to be carefully guarded against. The maxim is often quoted of "All work and no play makes Jack a dull boy"; but all play and no work makes him something greatly worse. Nothing can be more hurtful to a youth than to have his soul sodden with pleasure. The best qualities of his mind are impaired; common enjoyments become tasteless; his appetite for the higher kind of pleasures is vitiated; and when he comes to face the work and the duties of life, the result is usually aversion and disgust. "Fast" men waste and exhaust the powers of life, and dry up the sources of true happiness. Having forestalled their spring, they can produce no healthy growth of either character or intellect. A child without simplicity, a maiden without innocence, a boy without truthfulness, are not more piteous sights than a man who has wasted and thrown away his youth in self-indulgence. Mirabeau said of himself, "My early years have already in a great measure disinherited the succeeding ones, and dissipated a great part of my vital powers." As the wrong done to another today returns upon ourselves tomorrow, so the sins of our youth rise up in our age to scourge us.

"NOT A DROP OF FALSE BLOOD IN HIS VEINS."

THE value of character to a boy is well illustrated by this incident in connection with the late Civil War: The Confederate General Lee, in conversation with one of his officers, was overheard by a plain farmer's boy to remark that he had decided to march upon Gettysburg instead of Harrisburg. The lad watched to see if the troops went in that direction, and then telegraphed the fact to Governor Curtin, of Pennsylvania. The boy was sent for at once by a special engine, and as the governor and his friends stood about, the former remarked anxiously, "I would give my right hand to know that this lad tells the truth." A corporal promptly replied, "Governor Curtin, I know that boy. I lived in the same neighborhood, and I know that it is impossible for him to lie. There is not a drop of false blood in his veins." In fifteen minutes from that time the Union troops were pushing on toward Gettysburg, where they gained the victory.

Be honest, truthful, candid, in every relation and condition of life.

True candor is altogether different from that guarded, inoffensive language, and that studied openness of behavior, which we so frequently meet with among men of the world. Smiling, very often, is the aspect, and smooth are the words, of those that, inwardly, are the most ready to think evil of others. That candor which is a civic as well as Christian virtue, consists, not in fairness of speech, but in fairness of heart. It may want the blandishment of external courtesy, but supplies its place with humane and generous liberality of sentiment. Its manners are unaffected, and its professions cordial. Exempt, on one hand, from the dark jealousy of a suspicious mind, it is no less removed, on the other, from that easy credulity which is imposed on by every specious pretense. It is perfectly consistent with extensive knowledge of the world, and with due attention to its own safety. In that varied intercourse which we are obliged to carry on with persons of very different characters, suspicion, to a certain degree, is a necessary guard. It is only when it exceeds the bounds of prudent caution that it degenerates into vice. There is a proper mean between undistinguishing credulity and universal jealousy, which a sound understanding discerns, and which the man of candor studies to preserve.

He makes allowance for the mixture of evil with good that is to be found in every human character. He expects none to be faultless, and is unwilling to believe that there is any without some commendable quality. In the midst of many defects, he can discover a virtue. Under the influence of personal resentment, he can be just to the merit of an enemy. He never lends an open ear to those defamatory reports and dark suggestions which, among the tribes of the fault-finding, circulate with so much rapidity, and meet with such ready acceptance. He is not hasty to judge, and he requires full evidence before he will condemn. As long as an action can be ascribed to different motives, he holds it as no mark of sagacity to impute it always to the worst. While there is just ground for doubt, he keeps his judgment undecided; and during the period of suspense leans to the most charitable construction that an action can bear. When he must condemn, he condemns with regret, and without those aggravations that the severity of others add to the crime. He listens calmly to the apology of the offender, and readily admits every extenuating circumstance that equity can suggest. However much he may blame the principles of any sect or party, he never confounds, under one general censure, all who belong to that party or sect. He charges them not with such consequences of their tenets as they refuse and disavow. From one wrong opinion, he does not infer the subversion of all sound principles; nor from one bad action, conclude that all regard to conscience is overthrown. He judges others according to the principles by which he would think it reasonable that they should judge him. In a word, he views men and actions in the clear sunshine of charity and good nature, and not in that dark and sullen shade which jealousy and partisan spirit throw over all that allow these feelings to rule them.

Very much akin to lack of charity and good nature is insincerity. There is, in truth, no quality so degrading as insincerity. "You cannot," truly affirms F. W. Robertson, "in any given case, by any sudden and single effort, will to be true if the habit of your life has been insincerity." And James Russell Lowell very justly declares the result of his observations in these telling terms: "The only faith that wears well, and holds its color in all weather, is that which is woven of conviction and set with the sharp mordant of experience."

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

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FARMER BECOMES AN ELECTRICAL SUPERINTENDENT.

Before I began studying in the Schools, I was a farmer, and knew practically nothing about electricity or steam engineering. My Courses in Electric Power and Lighting and Stationary Engineering have been a source of great benefit to me, as I now have charge of an electric-light plant, and cheerfully admit that I owe my position and salary to the Schools. I think there is no better chance in the world for young men, without the means of acquiring a college education, to advance themselves than through the Schools. The value of the Courses cannot be overestimated.—*Stephen S. Yahner, Electrical Superintendent, Patton, Pa.*

FROM OFFICE BOY TO ARCHITECT.

When I was sixteen years old I left school to go to work in an architect's office. I had been in the office about six months when I heard of the Schools and enrolled in the Complete Architectural Course. About six months later I went to carpentering on buildings. I carpentered for about two and one-half years from the time of my enrollment, studying faithfully along with my daily work, bringing practice and education together. I am now twenty-one years old and have nearly finished my Course. I am employed as architect for Hotchkiss Bros. & Co., contractors, builders, and interior finishers, Torrington, Conn.—*Chas. S. Palmer, Architect, Torrington, Conn.*

FROM APPRENTICE TO ASSISTANT ENGINEER.

Having been a student of The International Correspondence Schools for over two years, I am prepared to give an unqualified endorsement of the system of instruction.

I can strongly recommend the Schools to all engineers, electricians, and their assistants who wish to qualify themselves for advancement. I speak from experience, as my Course in Electric Power and Lighting has been of the greatest benefit to me. When I enrolled in the Schools I was an apprentice, but from the knowledge gained in spare time, through the study of my Course, I have been able to obtain the position of assistant engineer in the power plant of The New York, New Haven, and Hartford Railroad Company. No one who enrolls in the Schools will ever regret the time or expense devoted to the acquirement of an education.—*H. Clifton Stone, Stationary Engineer, Providence, R. I.*

TRACKLAYER BECOMES MINE SUPERINTENDENT.

When I enrolled in the Complete Coal Mining Course of the Schools I was employed as a tracklayer, but after studying a short time I passed the examination for fire boss, and served in this capacity for four years. In the meantime I passed the examination for mine foreman, and am now holding a position as mine superintendent. As the result of my studies, my salary has been more than doubled.—*W. J. Neilson, Mine Superintendent, Federal, Pa.*

SECURES POSITION IN POWER HOUSE.

Before enrolling in the Stationary Engineers' Course of the Schools, I tried to educate myself by reading textbooks, but found that I could not understand them. While I have not quite finished my Course, I have progressed far enough to learn that, after studying in the Schools, books are not necessary, as the Course is complete in itself. Through the assistance of the Schools, I obtained the position of night engineer at the Columbia and Rensselaer Electric Railway and Lighting Company. As soon as my present Course is finished, I intend to enroll in the Electrical Course and obtain a thorough knowledge of electricity. — *Conrad J. Englert, Stationary Engineer, Rensselaer, N. Y.*

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Any mechanic who desires to advance to the top of the ladder (where there is plenty of room) will find the system of The International Correspondence Schools a success. The machinist who would succeed must have an education. He must be able to read drawings, to quickly and accurately transfer them to the surface of material and develop the various parts. The benefits derived from my Complete Mechanical Course are numerous. It has been a great help to me in my every-day work, and during the past year a position as draftsman, two foremanships, and a position as representative have been offered me. I am much pleased to note the progress made by several of my friends who enrolled at the same time that I did. I wish the Schools all the success they deserve.—*F. E. Griesmer, Machinist, San Francisco, Cal.*

ALWAYS RECEIVES HIGH WAGES.

The Course in Architecture which I have been taking through The International Correspondence Schools has been of great advantage to me. The Instructors have given me every attention and corrected my work with care and accuracy. I can recommend the Course. As a mechanic, it has taught me to solve the most difficult problems of my trade, and as a draftsman I have been able to make complete drawings and specifications of buildings. I have worked in several different localities, and have always received the highest pay and held responsible positions. My ability to do this is due almost entirely to the knowledge obtained through the Instruction Papers of my Course. As soon as I complete the Course, I intend to open an architect's office of my own.—*Geo. L. Kelly, Architectural Draftsman, Barry, Ill.*

PATTERNMAKER BECOMES DESIGNER.

In early life I had a desire to become a mechanic, and after completing a common-school education, I learned the trade of a patternmaker. While thus engaged, I further resolved to fit myself for a mechanical engineer. I heard of The International Correspondence Schools, and at once took up the Electrical Engineering Course. Today I am a designer of general machinery, with a good salary and fewer hours of labor. My progress has been very satisfactory, and I attribute it to the excellence of the Instruction Papers. These are the clearest and best textbooks I have ever used, and I unhesitatingly recommend the Schools to every enterprising mechanic as being thorough and practical.—*C. E. Mentzer, Machine Designer, Massillon, O.*

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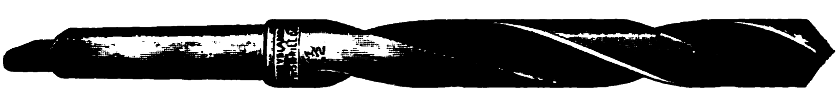

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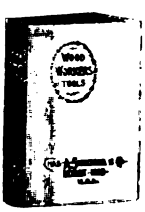

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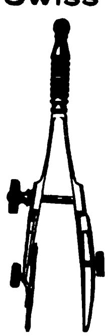

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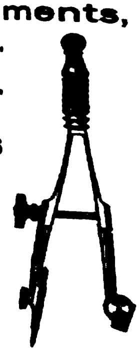

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THE MECHANIC ARTS MAGAZINE.

Vol. IV. SEPTEMBER, 1899. No. 8.

THE SIGNAL CORPS.

Louis Allen Osborne.

METHODS OF MILITARY SIGNALING—INSTRUMENTS USED AND THE MANNER OF OPERATING THEM—MODERN METHODS AND IMPROVEMENTS IN MILITARY SIGNALING.

WHEN you read in your morning paper the account of some important battle in the heart of the Philippine Islands, does it ever strike you that this information has come to you from the interior of a country where railroads' are few, telegraph lines fewer, and the only means of communication between some sections is on horseback? When General Shafter was in Cuba it was not unusual for the evening papers to publish details of events that had taken place the same morning in the interior of the island, and the officers of any army in active service must be in constant communication with the commander, no matter how widely the suborganizations may be separated. The duty of providing and maintaining this communication devolves upon the signal corps; and the signalmen detailed to accompany a battalion or regiment, as it marches out of headquarters camp, are of as much importance to that organization as is the lookout on board ship. The signal corps is the eyes and ears of an army. It must frequently advance beyond the main column, reconnoiter the country, and report back in detail anything that may be discovered. It must also keep the moving detachment in communication with general headquarters, and report each day all the details of its service to the commanding officer.

SIGNALING WITH THE FLAG.

The instruments used in signaling may be divided into two general classes; namely, those designed to produce on the receiver an impression of motion, and those designed to produce an impression of time. The former include the flag, torch, etc., and the latter comprise the lantern, heliograph, telegraph, etc.

When signaling with the flag, the signalman faces the station with which he desires to communicate, and waves the flag slowly but steadily from right to left to attract

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attention; or, if the station has a particular "call letter," he attracts attention by repeatedly signaling that letter until he is answered.

Behind him another signalman stands, or sits at a table and reads the message off,

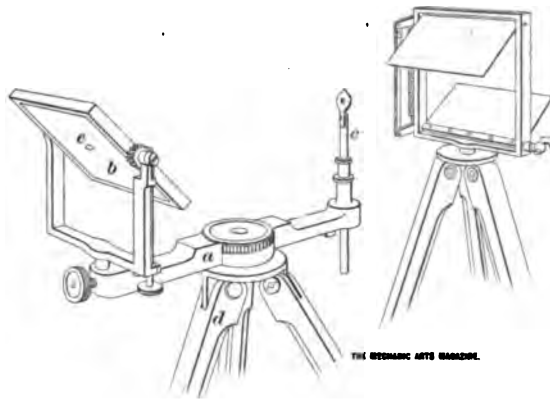


FIG. 1.

one letter at a time, and watches the receiving station carefully, to see that they receive the communication correctly—a result that they announce at the end of the message by signaling back "O. K." The letters of the signal alphabet are composed of a combination of the numbers 1, 2, and 3. A movement of the flag to the right of the sender indicates 1, while a similar movement to the left implies 2, and a dipping of the flag in front indicates 3. Thus, the letter R, which is 211, would be signaled by one movement of the flag to the left and two movements to the right. By means of the flag, messages can be sent about 10 miles on a clear day, using a flag 6 feet square, on a staff or pole 12 feet long. This method is very slow and laborious, however, and it is better usually to have two stations 5 miles apart, and repeat the signals with a 2-foot flag on a 4-foot pole.

At night the flag is replaced by the torch, and a foot-torch is placed on the ground, so that the observer may more readily discern the movements of the swinging torch by comparison with the one on the ground.

The slowness of the flag and torch renders them impracticable for general service, and the field telegraph or telephone is now relied on almost entirely. Before we consider this, however, there is another instrument that demands our attention, both on account of its simplicity and importance; this is the *heliograph.*

The heliograph consists of a brass bar, shown at *a*, Fig. 1. At one end of this brass bar is attached a frame carrying the mirror *b*, while at the other end is the sighting rod *c*. The instrument screws on the top of a tripod *d*, and is used as follows: The signalman sets the instrument by sighting through the hole in the mirror at *e*, and bringing the hole and the end of the sighting rod *c* in line with the distant station. He then inclines the mirror so that the sun shines directly on its face and is reflected therefrom toward the distant station; when the reflected shadow of the hole *e* falls on the end of the sighting rod *c*, the "flash" can be seen at the distant station. Another tripod is then placed in front of the first one, and on its top a shutter is fastened that can be operated to open and close, thereby causing intermittent flashes corresponding to the numbers 1 and 2, as in the previous case. For instance, a short flash would indicate 1, two short flashes would indicate 2, and a long flash is used to express 3. Messages can be transmitted with the heliograph almost as accurately and as rapidly as with the telegraph, but it is dependent on sunlight, and therefore cannot

RUNNING A TELEGRAPH AND TELEPHONE LINE.

be used in stormy weather or at night. It is very useful for temporary stations, however, as it can be readily operated a distance of 25 or 30 miles, if the elevation can be obtained at which both stations are clearly visible. There is, in fact, no distance at

which the heliograph cannot be operated when the air is clear, and each station is visible from the other.

The greatest distance the instrument has been operated in the United States is 82 miles. This was in the clear air of the Rocky Mountains, and by a detachment of the U. S. Signal Corps. The greatest distance the heliograph has ever been worked in the eastern part of the country is 47 miles, from the roof of the Capitol at Albany, N. Y., to a station in the Catskill Mountains. This was accomplished by the First Signal Corps of New York, at sunrise on July 18, 1893, after several unsuccessful attempts to pierce the haze with the reflected sunbeam.

The heliograph, then, although it is accurate, rapid, and easy of manipulation, cannot be relied on in climates where there is any uncertainty as to the weather conditions from day to day.

The telegraph and the telephone are, then, the only absolute and unfailing means of communication. A telegraph line several miles long may be erected in a day, and it can be guarded by a comparatively small number of men.

In laying a telegraph line, two or more of the signalmen carry knapsacks, on the top of which are reels containing ¼ mile of double cable. These reels unwind as they march along. and the other members of the corps in the rear attach the wire to trees at intervals, raise it on short thin poles, or hide it in the bushes and brush along the ground, according to the character of the country and degree of permanency required in the line. The erecting party are constantly in communication with every station along the line, as within the knapsacks under the reels the wires are connected up through an electric bell and telephone receiver. This bell can be rung at any moment and instructions telephoned to the advancing party. Should the instructions be in the character of a cipher despatch and require the telegraph in preference to the telephone (as is often the case), the officer in charge of the squad is so informed, and the operator, seen in the center of the illustration, steps up, throws out the telephone connection, and inserts the terminals of the key and sounder, which he carries in his hand. Telegraphic communication is thus opened with headquarters, while the local telephone service is suspended.

THE OLD WAY AND THE NEW.

Where an army is marching through an unknown country, it is frequently advisable to send a signal party to the top of some hill or promontory to reconnoiter the country, and telephone or telegraph back the results of its observations. When the party returns over the route on which they advanced, the wire is reeled up again, ready for future use. Should the main body of troops in the rear advance somewhat before the signal party returns, the rear end of the line is reeled up accordingly.

There are times, however, when all this system and scientific apparatus is of no avail, and the commanding officers are compelled to go back to earliest principles and send their despatches by orderly or courier. This method is slow and fraught with much danger, especially when in a hostile country. The messenger is liable to be intercepted or meet with an accident, and not be able either to deliver his despatch or to send back word of his failure; thus two portions of an army may be awaiting word from each other in vain, while the courier and his escort are prisoners, and important despatches are in the hands of the enemy's deciphering experts.

However, the old romantic picture of the mud-smeared and disheveled horseman, falling exhausted from his jaded horse, as he presents his despatch at the entrance of the general's tent, is now a thing of the past. The modern courier rides but short distances, and even then uses a bicycle in preference to a horse, if possible. The picturesque wagon train, the cattle, the horses, that were

driven in the wake of an advancing army, to provide the score of thousands of men and beasts with food and shelter, are now all rendered almost obsolete by the hand of science. Even in the remote Philippines, supplies are carried forward on railroads, which are built as rapidly as the army advances; and, instead of immense herds of cattle in the army's wake, piles of empty tin cans indicate that the patriotic cow sheds her blood in a Chicago stockyard and is shipped to the front in an embalmed condition. Hence, when we read in our morning papers of a skirmish at Mantilupa, the day before, it is safe to assume that no wearied signalman patiently wigwagged the news through with flag or torch, no tireless relay of couriers carried it through from the front, but that it was telegraphed over the military lines erected and maintained by the signal corps.

SMOKE PREVENTION.

C. P. Turner.

NOT IMPRACTICABLE, BUT PROFITABLE—SMOKE IS BUT UNBURNED CARBON—METHODS AND APPLIANCES FOR SECURING PERFECT COMBUSTION.

THE subject of economy in the use of fuel is one of great interest to all large manufacturers, and a great deal of careful study has been given to the methods that may be employed in burning coal so as to develop the greatest number of heat units for a given outlay. No matter how carefully the engine is designed and built, it can never utilize any part of the energy of the fuel that is lost through imperfect combustion. Any fuel that falls to the ash-pit unburned or that escapes from the chimney in the form of unburned carbon called smoke, or as a combustible gas, is irretrievably lost. No refinement in the form of elaborate designs of boilers, heaters, economizers, engines, and condensers will enable a plant to show a high degree of economy when, by the use of imperfect furnaces or through ignorance and carelessness of the fireman, a large percentage of the energy of the fuel is wasted.

A celebrated engineer, the inventor of a furnace for burning cheap grades of coal, has said: "The quantity of heat that can be obtained from a given grade of coal depends on two things: the percentage of carbon in the coal and the amount of brains you have under your hat." Since, with a given boiler and engine, the power that can be obtained from the coal is almost directly proportional to the heat produced by its combustion, it follows that the power value of a fuel is largely dependent on the degree of intelligence with which the firing is done.

In addition to the question of economy in the use of fuel there is, in most large cities, a most difficult problem, smoke prevention, which must be solved by the correct application of the principles governing complete combustion. The dense clouds of black smoke given off by factory chimneys add greatly to the discomfort of life in our large manufacturing cities. Granting that smoke, as is claimed by some authorities, is not in itself deleterious to the health of human beings, the murky atmosphere and almost perpetual cloudiness that it produces has a depressing effect that lowers the vitality of the inhabitants of a community, and the ever-present and unavoidable soot breeds a familiarity with dirt which, in all but the most cleanly, readily develops into a loss of pride in personal appearance and a disregard of the principles of sanitation. A superficial study of the conditions existing in the large cities and the various mining and manufacturing centers of our country, not alone of the slums but also the districts occupied by the well-paid workers, is sufficient to show that it is not so much the nationality of the workers or the nature of their employment that gives the inhabitants of our large coal-mining and iron-making centers their reputation for turbulence and vice, as it is the influence of the depressing and degrading effects of being constantly surrounded by an atmosphere and conditions that make outward cleanliness almost impossible. The careful housewife finds her best efforts almost unavailing in the never-ending fight against the black smudge that covers everything and pollutes the most carefully guarded of her household treasures, and she either falls an early victim to overwork or becomes indifferent to dirt of all kinds.

Another factor in the smoke problem, one that directly affects men's pocketbooks—the

point in which they are said to be most vulnerable—is the great damage done by smoke to household goods and stocks of goods in stores and warehouses. An inspection of any merchant's stock in a city in which much soft coal is burned will reveal quantities of goods damaged to a degree that destroys much of their original value, and, in any community other than a soft-coal center, would make them almost unsalable.

The loss from damaged goods is not the only direct money loss that is suffered by a community afflicted with the smoke nuisance. Daylight is shut out by the smoke clouds and artificial light must be used in its stead; poor light and the depressing influence of the general gloom lowers the efficiency of every worker; the immediate effect is a great increase in the cost of living and in the expense account of every business enterprise.

The many evils suffered by the inhabitants of smoky cities are vaguely felt, with the result that many smoke-prohibitive ordinances, the majority of which, however, have been so grotesquely inconsistent and impracticable in their provisions and methods of enforcement as to be self-annulling, have been proposed, and some have become laws. Few, even of the better class, of these ordinances have ever been effective to any appreciable degree, the only notable exceptions being those cities in which the use of soft coal is practically prohibited. It is urged by manufacturers that the prevention of smoke means their financial ruin, that furnaces which will burn soft coal without smoke are either wholly impracticable or that they are so expensive in the matter of first cost and maintenance as to make their use entirely out of the question. The public, being almost wholly ignorant of the theoretical and practical features of the case, are generally more ready to believe the statements of the men on whom the greater part of the business of their cities primarily depends, than they are to put any faith in patented smoke "consumers" or in the argument of theorists who assert that smoke *prevention* is not only possible, but that, in the end, the manufacturer himself will profit by it. In addition, there is the aversion of Americans to the work and worry involved in a fight for their public rights. They are probably the most long-suffering and, in some respects, the laziest people on the earth, and, rather than carry on a vigorous fight against the most flagrant public abuses of their rights, will patiently submit, grumbling a little, perhaps, but accepting loss and discomfort much as they do the effects of the idiosyncrasies of their climate.

It can be positively asserted, however, that smokeless cities, even in the heart of our large manufacturing districts, are not the wild dreams of visionary theorists; on the contrary, they represent a condition that is not only desirable from a sanitary and moral standpoint, but profitable to all business interests, including those of the manufacturer himself, and entirely practicable when regarded as a problem in engineering.

Some of the more heroic measures that have been suggested as remedies for the smoke nuisance are excellent and have already done something in mitigating its evils. Gas engines and electric motors have replaced small boilers and engines in light manufacturing establishments, and have removed many of the worst offenses, and those in which the engineering difficulties were greatest. Gas stoves and steam heating for domestic use have also opened up a method of dealing with the smoky kitchen chimney—individually insignificant but collectively an important factor in the problem. The central stations from which steam, gas, and electricity are distributed, may be located far enough away from business and residence centers to prevent the smoke they develop from being a nuisance; better still, with such large units the most approved devices for burning coal without smoke can very profitably be used. Under the favorable conditions prevailing in a large modern central station, smoke prevention is one of the simplest of the problems presented to the designing and operating engineers, and a failure in this respect is an indication of almost criminal incompetence on the part of either the designer of the plant or the engineer in charge of its operation.

There is, however, a large class of power users whose needs are not met by the central station in its present state of development. Numerous establishments in every city are so situated that they can develop their own heat, light, and power at a much lower rate than the central station can, or at least will, furnish them. If the establishment is a large one, use can profitably be made of the appliances employed by the central station, and the problem becomes a simple one. Failure in this case is no more excusable than in the case of the central station.

The most serious difficulty arises when we consider establishments in which the fires can easily be handled by one or two men.

Here, little or no reduction in the labor cost can be effected by the use of automatic stokers or other mechanical devices for feeding and controlling the fires. It is also generally conceded that, in their present state of development, automatic stokers are no more economical in use of fuel than hand-fired furnaces that are correctly designed and carefully managed, the only possible exception being those cases in which the automatic furnace is used with very low grades of fuel, that cannot be successfully burned by ordinary methods of firing.

There are numerous devices and special methods of furnace construction, many of which are patented, whose purpose is the prevention of smoke with hand firing. Some are based on correct principles, and, when properly applied and intelligently used, are of considerable value; very many, however, belong to the cure-all class of remedies, their very name, smoke "consumers," being an indication of a catchpenny character. The very best special furnace or attachment will be a failure in the hands of an untrained or careless fireman; with a competent man these devices are useful only as aids to a correct application of the principles governing smokeless combustion.

Numerous failures have followed attempts to use the better smoke-prevention devices under unfavorable conditions or in the hands of incompetent men; these failures, in connection with the absolute frauds and the utterly absurd claims made by many builders and agents, have given an undeserved bad name to all devices of this kind and done much to discourage their legitimate use.

One of the greatest obstacles in the way of smoke prevention in small plants is the fact that the demand for steam is often greater than can be supplied by any but the most wasteful methods of firing. Either the growth of the plant has not been accompanied by a corresponding increase in the capacity of boilers and furnaces, or they were originally too small to do their work economically and well. The result is that the fires must be forced, regardless of smoke or waste. A management that permits this condition, generally sees economy in employing a cheap fireman, with the result that a bad matter is made still worse, and the general public must suffer for this inexcusable greed and ignorance.

In spite of all its apparent difficulties, there is nothing in the problem of smoke prevention in small plants that cannot be solved by the application of simple and well-known engineering principles. Furnaces can be proportioned to suit the demand for steam and the quality of the fuel. The worst cases of insufficient draft can be cured, either by a correctly proportioned chimney or by some system of artificial draft. Such special devices as practical experience and correct scientific principles show are applicable may be used as aids to trained and intelligent firemen, on whom, however, the first dependence must be placed.

In the small plant, the mechanical uniformity of firing, which, under the more favorable conditions of the large plant, is profitably obtained by the use of automatic stokers, must be supplied by the vigilance of a well-trained and intelligent man, a man who is not only able to understand all the principles involved and the best methods of applying them, but is also willing to devote his time and attention exclusively to his work. Intelligence and application of this order command wages considerably in excess of that given to ordinary labor; money so invested will, however, pay large and immediate dividends in fuel saved and in a decrease in repair bills. Further, the public has a right to demand that all means for eliminating the smoke nuisance be utilized to the greatest practicable extent.

As a brief summary, the following outline is presented of a plan that may now be utilized to free our cities from smoke without prohibiting the legitimate use of soft coal, the fuel on which our manufacturers must largely depend: The by-product system of coking is to be made to furnish gas for domestic heating and for the operation of gas engines in small manufacturing establishments; it will also furnish a supply of coke for those purposes where a smokeless solid fuel is essential or desirable. Large central power stations, in which the most approved automatic stokers may be profitably used for burning any grade of soft coal without the production of smoke, are to furnish electric current for heat, light, and power; they will also supply compressed air and hydraulic power for the particular purposes for which these systems are specially adapted. To a certain extent the central station can also profitably furnish steam for heating purposes. Finally, an intelligent supervision of all plants, one that will insure such a construction and management of boilers as will effectually prevent smoke, must be maintained.

This outline involves no untried or doubtful engineering expedients; each feature has

been proved by actual practice to be successful, and the manufacture of gas and the use of central stations are rapidly becoming profitable commercial enterprises, and already have a beneficial effect. It now remains for the people to demand that the pollution of the air they breathe be as thoroughly prevented as is the poisoning of their water supply by scarcely less harmful waste products.

A LESSON IN FREEHAND LETTERING.

Chas. J. Allen.

LETTERING USED EXCLUSIVELY BY MECHANICAL DRAFTSMEN—STYLES OF LETTERS USED FOR TITLES AND WORKING DRAWINGS.

THE lettering and figuring of drawings is treated by many draftsmen as a matter of slight importance—as altogether secondary to the drawing itself. In fact, the general appearance of many drawings is greatly marred and in some cases entirely ruined by slighting the formation of the letters used in the title or in the description of its parts, while the drawing itself may be executed in a perfect manner.

Perhaps the reason for poor lettering on drawings is that some draftsmen have a natural dislike for attempting anything in the line of freehand work, or they may never have had a helping hand, either in the form of practical hints or by having had access to some good volume treating on the subject. A class of draftsmen may be mentioned (though not to their credit) whose pride in their work ceases with its completion exclusive of the lettering, and who are satisfied to express the description and measurements in any irregular form of letter or figure. But for the benefit of the progressive draftsman, the few illustrations and suggestions contained in this article are contributed with the desire that he may find them of profit, and an incentive to a further study of styles and systems of lettering.

The styles of letters used for working drawings will first be considered. These are severely plain and free from any embellishment; therefore, only such styles are used as can be made with rapidity, and show throughout their construction a uniformity and symmetry that is only possible to obtain in lettering by following the established forms and rules. At first these rules may seem to be somewhat of a restraint to the draftsman, but by practice they soon become fixed in the mind. The styles described here have become, by common consent among the leading draftsmen throughout the country, the popular styles used.

The capitals and lower case, with their corresponding numerals, are used more than any other form of letter, and to them we invite the reader's careful attention, while we note the characteristic features of each letter.

FIG. 1.

The capitals should be twice the height of the lower-case letters, as shown in Fig. 1. The slope of all letters and numerals, as determined by the map department of the United States Geological Survey, should be three parts of base to eight of height, as shown in Fig. 2, this having proved to be the most natural incline to maintain in lettering. And here a word might be fittingly spoken regarding a strict observance of this slope, as one letter in a word not parallel with this line causes the entire word to appear distorted.

The capitals, although single pen-stroke letters, are made proportionate with the Egyptian, or, as designated by printers, the Gothic style. These should be somewhat condensed from the normal width of the letter, or the width should be $\frac{1}{2}$ the height, with the exception of the *E*, *F*, and *L*, which are $\frac{1}{8}$ narrower, and the *M* and *W*, which are $\frac{1}{4}$ wider. The middle bar of the *A* is placed $\frac{1}{4}$ the height of the letter above the bottom line, while the middle bar of the *B*, *E*, *F*, *G*, *H*, and character *&* are $\frac{1}{8}$ their height above the center of the letter, and the *P* and *R* are the same distance below the center line. The *O* and *Q* are perfectly elliptical, and the *C* and *G* should be made to conform to them as nearly as possible.

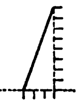


FIG. 2.

The lower-case letters of this style should be spaced with great accuracy, allowing as little interspace as possible between letters. These letters should be $\frac{1}{2}$ the height of the capitals. Letters extending above the line should reach the height of the capitals, while those extending below the line should be shortened somewhat. The principal feature of the lower-case letters is shown in Fig. 3. The oval, or egg, shape is used in two positions—the dotted lines showing all letters in which it occurs, and the proper relation of this characteristic feature to the rest of the letter. In Fig. 4 is shown another component feature of these lower-case letters, occurring in the letters *h*, *m*, *n*, and *u*. Those who closely observe letters and the motive expressed in every line and curve will readily trace this to its prototype, namely, the script. This curved line is tangent to the main stroke, $\frac{1}{8}$ the height of the letter below the upper and above the bottom lines. Where two letters *f* occur in a word, the second is usually carried below the line, as shown in Fig. 1. Great care should be used in making the numerals occupy the same position of incline as the capitals, as few of the numerals possess a vertical stroke. The ellipse of the *6* has its axis on a line with the top of the upper stroke, and a line drawn from the center of the top of the *7* gives the point reached by the slanting stroke on the bottom line. The same characteristic that occurs in the *3* is shown in the *8*, which has its lower portion joined on the upper, which is a perfect ellipse. Fractions are expressed, as shown in Fig. 1, by using the dividing bar, or this may be omitted, in which case the figures can be made larger.

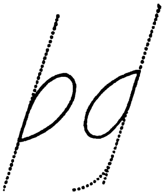


FIG. 3.

Another pen-stroke letter, very popular with draftsmen, especially for descriptive work in preliminary or unfinished drawings, is shown in Fig. 5. This style of letter, if stripped of all the ornamental attachments shown in the figure, can be made with greater rapidity than any other letter used, the slope to the left being the reverse of Fig. 2.

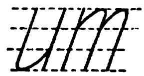


FIG. 4.

Shaded letters are sometimes used by the draftsman where the lettering is of such a nature as to require distinction in its general character from other descriptive matter. The Italic, or half-script (as it is sometimes called), shown in Fig. 6, fills this requirement, showing a marked difference from that of Fig. 1, and is also a letter easily made on account of its likeness to the script, which

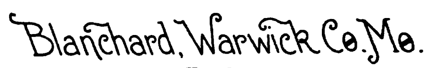


FIG. 5.

is familiar in its points of construction to every draftsman. The capitals used for this style of lettering are the Roman Italic, and require considerable study and practice to insure giving them their proper proportion and slant. The Roman figures are used with this style of letter, or the single-stroke numerals may be used.

The selection of the proper letter to be used for a title should by no means have a secondary place in our consideration. The title is the most conspicuous part of the drawing, and is usually composed of very few letters, so that the draftsman can well afford to make these few letters appear to the best advantage within the possibilities of his skill as a letterer. There are but few styles used for this purpose. The Half Block, Egyptian, Antique Egyptian, and Roman, shown in their respective order in *a* and *b*, Fig. 7, *a*, Fig. 8, and *c*, Fig. 7. These letters are easily constructed, so that, by a careful study of Fig. 7 and the principles shown in these three letters, the draftsman who has confined himself to one style of letter may find in them practical suggestions for a new field of practice.

The Half Block is entirely a mechanical letter (or is made by the use of the pen and ruler); *b* and *c* are freehand letters, but

system has rendered their construction as simple as the former. This Half-Block letter is comprised in a rectangle whose width is $\frac{4}{5}$ its height, divided as in *a*, and it might well be classified as a kindergarten letter, on account of its being the simplest form of letter in use; and the block system by

FIG. 6.

which it is constructed not only insures the proper width of the letter, but gives it a uniform stroke. It is, therefore, the popular letter for titles on drawings. There are many draftsmen, however, who are not confined to mechanical lettering for titles. As all lettering on drawings, exclusive of the title, is freehand, it should be regarded as no breach of harmony in employing freehand lettering throughout the work. In drafting rooms where this is not allowable, it is on account of the limited knowledge of this subject among draftsmen that causes them as a whole to employ the kindergarten letter referred to.

If the reader will turn his attention to some of the plainest freehand letters, and will note the simplicity with which they are constructed, he will find that the two styles *b* and *c* of Fig. 7 are not as difficult to make as he may have supposed. The same lined rectangle is used for *b* as previously described for *a*. Place 12 points as follows: On the vertical line marked *3* at all intersections of horizontal lines, on *1* midway between *b* and *c*, and opposite this on *2*, and likewise on *5* between *d* and *e*, and opposite on *4*; also, at points *5 b* and *1 e*. From point *3 a* to *3 d* draw a semiellipse, tangent to the point between *b* and *c* on *1*, and from *3 b* to *3 c*, parallel with the first

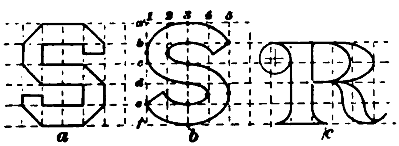


FIG. 7.

line drawn, and from *3 a* to *5 b*. The end of the stroke is cut off on an angle parallel with a line drawn from *5 b* to *1 e* on which the curve is finished from *3 b*. Having performed one half of the letter *S*, it is an easy matter to reverse the operation and complete the letter. Great care should be exercised in making the stroke of all round letters of this Egyptian style uniform in width.

The Roman letter *R*, shown in *c*, Fig. 7, is made by drawing five horizontal lines at an equal distance apart, crossed by five vertical lines, making 16 squares of equal size. The stroke of this letter occupies a square in width, and is the same at the maximum width of the crescent, as it is at the double-curve tail of the letter. The spur of the Roman letter is one-quarter of a circle whose diameter is $1\frac{1}{2}$ times the width of the stroke. The tail of the *R* is located by equally dividing its width by a line vertical with the inside of the crescent stroke, and this tail is drawn by uniting two ogee curves at the ends, the curves being reversed at line *4*.

The letter shown in *a* of Fig. 8 (the Antique Egyptian) is the same in contour as example *b*, Fig. 7, with the exception of the spur, which is the characteristic feature of this letter. The heavy shade shown on this letter, giving it a beveled effect, is but a letter-face treatment, and forms no part of the style of the letter.

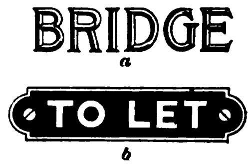


FIG. 8.

The cut-in letters shown in *b* simply require a filling in of the panel, after the letters have been first outlined, and the lines drawn forming the panel and leaving the letters white. This method, for the small amount of extra time and work expended, gives a most pleasing effect for a title on a drawing. The draftsman should use great care in locating his descriptive matter on a drawing, that it may not be mistaken as applying to some other part than that intended; especially is this true when an open space is used, somewhat removed from the point referred to. The arrow should never be omitted when this occurs.

In working drawings, such as a bridge elevation or other similar work, the descriptive matter should follow the same angle as the portion to which it refers. Topographical maps are very liable to appear crowded and confused unless due regard is paid to the direction the letters point, the proper size and form of letter used to express every component part of a map, the waterways according to their importance; mountains, cities, towns, etc. all have an exact size and form given them according to regulations prepared by the map department of our goverment.

IN THE WORKSHOP.

(Continued from the August, 1899, Number.)

H. Rolfe.

Fitting in Motion Pins—Desiderata in a Bearing—Something Else Required Besides a Smooth Surface—Scraping Up Slide Valves and Seats.

AGAIN, link-block pins, eccentric-rod pins, etc. are made a good but free fit; these want to be just as good a fit as will let enough oil get to them. The pins are turned up and the holes drilled true and smooth. After all parts are hardened, the pins are buffed and the holes lapped out if required. Now, if these holes were made so that when quite dry the pin would just move through without any seizing—like a ring-and-plug gauge, in fact—it would be too tight a fit when working, for there would be no room for the oil. A pin of this kind may have an appreciable amount of shake when all is dry and clean, and yet be a good fit when oiled. It must also be remembered that, when lapping out, the hole will get quite warm and so be larger than when cool. As to the amount of play in the hole—well, we never tried it over, but should say it was about half a hundredth.

These motion pins are preferably made of wrought iron, and case-hardened. With care in the quenching, they come out pretty

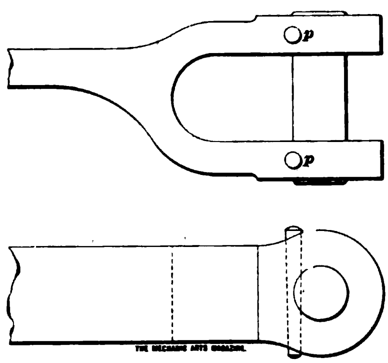


Fig. 1.

straight. Clean them up in a lathe with emery clamps, and if found to be at all oval put them on the buff; they may then be all right in the holes, perhaps a little slack, in fact. If, when cleaned up, they are found not to be oval, simply lap them into the holes again, for they are sure to be large all around—pins will seldom go into the holes after hardening, for they nearly always shorten and swell, and the holes also close in a little in quenching. In buffing a pin like that in Fig. 1, it is advisable to work chiefly on the side where the taper pin sets; this will insure the pin p bearing well on the groove, and yet not sufficiently so to impair

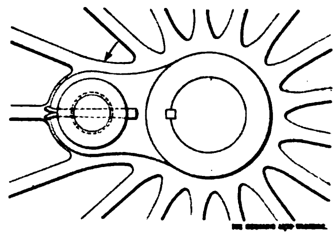


Fig. 2.

the general tightness of its fit. It may be added that these pins and that shown in Fig. 2 should project from the hub a distance equal to the diameter of the pin. This is chiefly a matter of appearance. Even if the designer could feel assured that the pin would never be driven down at all, he should make it stand out that amount when new. There is another small matter of detail connected with these taper split pins that may be mentioned. If the split end of the pin is left too short, it is liable to crack when opened out, if the edge of the pin hole is left square as is the general custom. The next time the side rod is taken down, all the force of starting the pin comes on the split end, and even if it stands that, it is almost sure to break when next it is opened out. To secure a long bend and avoid the unsightliness of the pin projecting too far through the collar, we could countersink the hole as shown in Fig. 3, using only a slight taper and making the profile of the tool a little hollow. Now, some draftsman may remark on the cost; he has perhaps been pulled up by his chief at some time or other on account of cost of production, and ever afterwards has worked this idea (of cheapening things) to the point of overdoing it. The above idea, however, cannot be deemed a very expensive one—it's worth the outlay, anyway. As a finishing touch to these pins,

just make a nick with the file edge along the split in the bottom end; the erector who has to open them out will appreciate it.

While discussing cases of overdoing it, something may be said about getting up a bearing too carefully. The tyro thinks that because a bearing requires, broadly speaking, to be *smooth*, it should therefore be as near like a mirror as he can get it. Now, when this is so, the oil has difficulty in getting in and keeping there, especially if it is a poor thin oil or the parts are at a high temperature or under excessive pressure. We may, at the outset, lay it down as a principle that all bearing surfaces should be left as they come from the machine. It may be a main crankpin brass, a driving brass, or a slide valve—in all these and similar cases, if the bearing is sufficient and in the right place, don't touch it. Sometimes a valve will spring a little when taken out of the planer or lathe; it must then be brought to a bearing with file and scraper. The latter tool is handy in the final stage, but do not attempt to give the face a "motley" finish, as though you were making a boiled-oil joint. Again, a brass may bear on the fillets; if so, ease them off. Or the journal may be hollow (or the reverse), and the brass have been bored out straight; if so, bring it to the proper bearing.

If a driving box, it should be bored out small, and then eased at the sides (at *m*, *m* in Fig. 4), so as to bring it to bear at *n*, *n* and clear $\frac{1}{32}''$ at *o*. If a main-rod brass, bore it out with a piece of thick tin in the joint; it will then, when put up (without the tin, of course), be about $\frac{1}{32}''$ bigger top and bottom than fore and aft; the brass ought not to want touching at all.

The case stands thus: To insure a bearing running cool, we must look after four things:

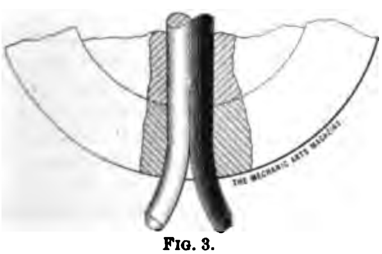


FIG. 3.

(1) see that everything is fair and square; (2) have a sufficient bearing surface and in the right place; (3) give a proper amount of side play; and (4) have a free and liberal lubrication.

As regards (1): See that the main rod is "out of winding" and that the brass is bored out fair. The rod should be in such condition as to stand the following test, if applied: Couple up the front end and see if the stub end of the rod stands fair with the main pin; then uncouple the front end and couple up the back end, and see if the front end stands fair with the wristpin. If

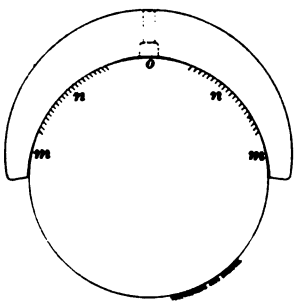


FIG. 4.

O. K. at both ends, we know there will be no cross-binding on the rod when all coupled up. By "standing fair" we mean that not only should the rod end, as a whole, be square with the pin, but that it should also have no twist in it. Thus, the two bearings should be parallel with each other as viewed both in plan and elevation, and also each be normal to the vertical axis of the rod. If this is so and the wristpin is horizontal and square with the line of stroke and the main crankpin is bored fair into the wheel hub and the pedestals are square with the line of stroke, we have condition (1) satisfied, so far as the main rod is concerned.

As regards (2): The main-rod brass should bear as shown by the dark lines in Fig. 5. If a brass is bored out while sweated together, the clearance at top and bottom must be filed, finishing off with the scraper. If reboring old brasses (as when a fresh pair of wheels with larger journals have been put in), insert a piece of sheet iron $\frac{1}{32}''$ thick in the joint and bore out to, say, $6\frac{1}{32}''$. Then, when the iron is taken out and the brass keyed up, the diameter back and front will be 6'' and top and bottom $6\frac{1}{32}''$. This scheme can also be adopted in new work, the brasses being keyed up in the strap, or else clamped together if the rod has a forked end. The brass should in no case bear on the fillets.

The driving box should be bored out fair—parallel with the side faces where it fits into the pedestal, and also at right angles to the flanges of box. It is of little use having a box show a good and sufficient bearing when tried separately on the journal, if the thing is going to be twisted out of square when the engine is wheeled. A driving box should be bored out $\frac{3}{32}''$ smaller than the journal, so as to keep it off the crown.

Young mechanics (and a good many old ones too, for that matter) fail to discriminate between driving and "carrying" wheels, when fitting the boxes up. The action of the main rod tends to make the journal knock inside of the brass; now, if the crown of the brass is let down on to the journal in the first place, it will bear on there still harder when the engine is wheeled, and the effect will be that of a journal in a brass of larger diameter than itself, as shown exaggerated in Fig. 6. It will be readily seen how such a journal will move to and fro under stress of the steam. All brasses, in short, ought to be fitted as in Fig. 4, clearing the journal about $\frac{1}{32}''$ at the crown *o* and bearing only on the hatched portions *n*, *n*. A day or two's wear, aided by the weight of the engine, will bring the brass to a bearing *n o n*, and this bearing will be so "solid" as to prevent any knock between journal and brass.

Some people make the bearings extend all round to *m*, *m*, their idea, we will charitably suppose, being not so much to give extra load-carrying surface as to insure against knock. But where round brasses are used, the tendency is to close in under the weight of the engine and the wearing of the brass, this tendency being aggravated if the latter gets hot. Hence, the brass is liable to grip the journal at the sides, and it does not take much of this kind of thing to annoy a journal and make it seize.

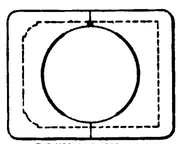


FIG. 5.

Concerning (3): It is very important that a bearing have proper side play, whether it be a driving box, a main rod, or a side rod. The erector has no latitude in this matter, on new work; has only to see that the drawing is carried out. On repairs, however, if "working in" strange brasses, or lining up boxes and brasses sideways, he must see that the right side play is given in the lathe or boring mill. The nature of the road has a lot to do with the amount allowed—from $\frac{1}{8}''$ to $\frac{3}{16}''$ lateral play for driving boxes, besides the play in the box flanges. Main rods are given $\frac{1}{32}''$ at the front end and $\frac{1}{16}''$ at the back. (In European practice—inside cylinders—they have $\frac{1}{8}''$ at back.) Side rods on ordinary roads should have $\frac{1}{16}''$; on very sharp curves, twice or three times this is often given. Sometimes the rear crankpins are made spherical—having then no side play.

As regards (4): The most general practice has been to feed the oil through a hole in the crown of the brass, an oil groove extending the whole length of the bearing, except about an inch at each end. This groove is generally made $1''$ wide, which is twice as much as necessary, and is, anyway, to be deplored, as it robs the brass of bearing surface just where it is most valuable. Two $\frac{1}{2}''$ grooves, $3\frac{1}{2}''$ apart, one on either side of the center line, would be worth a trial.

The cellar should be provided with a proper pad or sponge to soak up the oil carried around by the journal and restore it to the latter. It also keeps the dirt and grit off of it. Use a good oil in preference to grease; never use valve oil. Keep all worsted trimmings clean.

To return to the main point: It is useless to get up too nice a face if the above four items have *not* been attended to, and if they *have*, it's unnecessary. Consider two bearings A and B, equally in trim as regards the above conditions, A however not having been touched since leaving the machine, preserving all the little ridges left in by the tool (a spring tool should never be used), while B has been got up with a scraper till the journal, when rubbed with the hand and a mere speck of marking, "spots" it all over. Well, we claim that of the two, A will run the cooler every time.

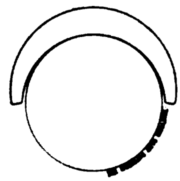


FIG. 6.

Again, some workmen will scrape away at slide valves and seats till they are as smooth as glass. Their next door neighbor, being a wiser man, will just try his valve over with the surface plate to see if it has sprung at all when taken out of the machine, and if so, will dress it down with file and rough scraper. All he wants to insure is that both the surfaces are plane and true. If he can leave them with the tool marks in, so much the better, the result being that the valve and seat will not show a quarter of the wear that the other will; this saves power and expense of renewals, for the oil will remain in the numerous small hollows or grooves, the valve in fact seeming to float on its seat—and not to have that more perfect and metallic contact, which causes the wear. Treating the faces thus, is the more necessary as the great heat in the steam chest vaporizes the oil and robs it of its body—thus letting the valve down on to its seat.

(*To be Continued.*)

DESIGNING MACHINERY.

D. Petri-Palmedo.

A LINE OF DESIGNS—TRUE FORMULAS—DIAGRAMS—EMPIRICAL FORMULAS FOR DIMENSIONING. POLES—UNITS—PROPORTIONAL CHARTS—CROSS-SECTION PAPER.

PART III.

LET us now suppose that the firm with whom we have placed our young designer is meeting with success in selling their new style of press, that orders come in for different sizes, and that therefore it is decided to invest in new patterns for a whole line of presses. The original machine having stood the test, it is taken as a basis from which the other sizes shall be evolved. Here, then, is another of the jobs that fall to the lot of the young designer. He is given the complete set of drawings of the original machine, and necessary data as to sizes required, and learns that there are to be machines varying in power as well as in throat depths; for instance, for the machine of 230,000 pounds pressure there are to be nine different frames, with throat depths of from 12 to 60 inches, varying by 6 inches.

Now, we have seen that a change of throat depth affects the strength of the frame considerably; we have also seen that the bending stress produced by the load is inversely proportional to the moment of inertia I of the section. This moment of inertia increases very rapidly with the dimensions h_0, h_1, etc., while it grows but slowly with increase of the dimensions b_0, b_1, etc.; in other words, we should strengthen the frame by increasing the depth h_0 rather than the width b_0. So long as the pressure P remains the same, there is no need to increase the width at all, as the diameter of the main shaft and the other parts of the mechanism are but little, if at all, affected by the change of throat depth. For the line of frames, then, for the same power as that of the original press (that is, 230,000 pounds), we can leave the dimensions b_0, b_1, etc. the same, and simply change the dimensions h_0, h_1, etc. in a certain proportion, which remains to be determined, in the shape of a factor with which to multiply h_0, h_1, etc. Calling this factor x, and noting that $A_0 = b_0 h_0$, $A_1 = b_1 h_1$, etc., we shall have for the new section:

$$A_0' = b_1 x h_1 = x b_0 h_0 = x A_0;$$
$$A_1' = x b_1 h_1 = x A_1;$$
etc.
$$A_0' h_0' = x^2 A_0 h_0; \quad A_0' h_0^2 = x^3 A_0 h_0^2;$$
$$A_1' h_1' = x^2 A_1 h_1; \quad A_1' h_1^2 = x^3 A_1 h_1^2;$$
etc. etc.

From these, following up the formulas given in Part II of this article, we easily establish

$$a' = x a;$$
$$h_0' - a' = x (h_0 - a);$$
$$I' = x^3 I.$$

Now, as the maximum stress is not to be greater than in the original machine, we have the equation

$$T = \frac{P}{A} + \frac{P}{I}(t + a) a = \frac{P}{x A} + \frac{P}{x^3 I} (t_x + x a) x a,$$

which leads to the quadratic equation for x:

$$x^2 - x \frac{I + A a^2}{I + A (t + a) a} - \frac{A t_x a}{I + A (t + a) a} = 0,$$

making
$$\frac{I + A a^2}{I + A a^2 + A t a} = M;$$
$$\frac{A a}{I + A a^2 + A t a} = N.$$

Solving for x we get

$$x = \frac{M}{2} + \sqrt{\frac{M^2}{4} + N t_x}$$
$$= \frac{h_0'}{h_0} = \frac{h_1'}{h_1} = \frac{h_2'}{h_2}, \text{ etc.},$$

based on the condition that the tension in the frame shall not exceed a certain limit. It is evident that a different value for x would have been the result if the calculation had been based on the compressive stress C in the frame. Both results, however, show that the ratios $\frac{h_0'}{h_0}$, $\frac{h_1'}{h_1}$, etc. are by no means equal to $\frac{t_x}{t}$; that is to say, it would have been a grave mistake to increase the dimensions h_0, h_1, etc. in the same proportions as t. The ratios for tension and compression being different, it will become necessary each time to calculate both stresses for any adopted value of x, and to change the dimensions until the stresses are right. It is thus seen that the process of laying out sizes is by no means a simple one, but involves a great amount of calculation back and forth.

After the frames for these presses are well worked out, they are practically done, as the

other parts, shaft, eccentrics, etc. remain the same; the length of the shaft, of course, changes with the throat depth, but, as in such machines the diameter of the shaft is chosen so as to give it excessive strength, it will in most cases be rigid enough to resist undue distortion, though increased somewhat in length.

It is different for the other sizes, varying in power. Taking again the original machine as a basis, the working parts must be changed, and in these cases, it is these parts that will determine the general dimensions; the shaft is subjected principally to torsional stress, and, as its resistance to torsion increases with the cube of its diameter, it is evident that the shafts do not increase in diameter in the same ratio as the loads. Moreover, the stroke will have to be changed also, making matters still more complicated than in the case of frames for different throat depths but equal powers.

To simplify the labor connected with laying out sizes, various methods are resorted to, the three principal ones being formulas, tables, and charts. We have already advocated the use of formulas as most efficient time savers whenever practicable, but have also shown that the tentative method must be resorted to as soon as the given conditions in the problem become too numerous or indefinite. In such a case the problem must be subdivided, and each division probed as to its underlying conditions, which, when sufficiently definite, may then allow of a treatment by formulas.

It is this "probing for conditions" to which we wish most especially to draw the young designer's attention, in order to guard him against the indiscriminate use of formulas given in pocketbooks, manuals, and college textbooks. *Most of such formulas are true and useful only under the special conditions on which they are based.* Thus, to revert once more to our example of the punching press, we have to calculate the shafts anew for the other powers, and in doing so may be tempted to refer to some authority in the shape of one of the numerous pocket memorandum books, giving under "shafts" various formulas of the forms

$$d = C\sqrt[3]{PR}, \text{ and } d = C_1\sqrt[4]{PR},$$

of which the former gives the diameter d of the shaft under the condition that the torsional stress caused by the load P acting on an arm R is not more than a predetermined amount per square inch, and the latter under the condition that the torsional deflection of the shaft does not exceed a certain predetermined angle per foot of its length. C and C_1 are constants, varying with the material and with the action of the load—that is, whether acting continuously or intermittently, whether constant or varying in magnitude, whether productive of stress always in the same direction or reversing at times, and so forth.

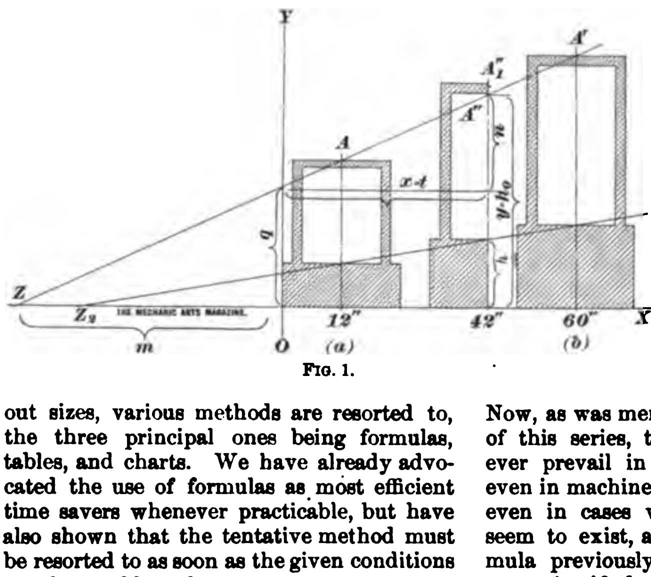


FIG. 1.

Now, it is evident that, when a book of formulas gives, as many actually do, only the above formulas, with fixed values for C and C_1 without further comment, they are worse than useless; and if, as is done in the better books, various values for the constants are given for different conditions and materials, the formulas are applicable only under the same conditions. Now, as was mentioned in a previous article of this series, the *same* conditions hardly ever prevail in two different designs, not even in machines of the same class, so that, even in cases where the same conditions seem to exist, and where the use of a formula previously established for the same seems justified, the results should always be checked in every way possible. For instance, in the case of the shafts in our example, if we have made use of any formula for the diameter, we should calculate the stresses produced by the load, and also the deflections, and compare the results with the figures furnished by experience as limits for safe working stress and distortion.

When it is clear from the foregoing that formulas are to be used with caution, and only with full understanding of conditions

on which they rest, it is at once evident that tables and charts or so-called diagrams are still more to be regarded as applicable only under special conditions. They are tabulated and graphically represented results of formulas, and as such are not only heirs to the peculiarities of the formulas, but have moreover lost the structure indicating the relations between the various determining elements.

We cannot leave the subject of formulas and charts without making reference to a special kind that has great prominence in

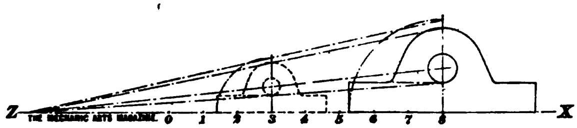


FIG. 2.

all matters pertaining to machine design. These are the *empirical* formulas and the *proportional* charts. The difference between these and the formulas and diagrams above referred to is that the latter are true for the same conditions for any magnitude of the varying elements, while the empirical formulas and proportional charts are true only between certain limits. Thus, the above formulas for the diameter of a shaft are true for the same permissible working stress, no matter how small or how large the shaft may be. They are based directly on the theory of the strength of materials. In the shape of diagrams or charts, the two formulas can be represented by a cubic and biquadratic parabola, respectively. The empirical formula is not so derived, but is the expression of the mean relation between certain variables in a more or less numerous collection of cases in actual existence. They form the greater part of the data and information contained in text and note books on machine design. To give an example: The familiar rule for the diameter of the inscribed circle of the hexagonal bolt head or nut is

$$D = 1\tfrac{1}{2}d + \tfrac{1}{8}''.$$

This holds good for all ordinary sizes between $\tfrac{1}{4}''$ to $3''$ bolt diameter, and says that, if the nut diameter D be made $1\tfrac{1}{2}$ times the bolt diameter simply, it would be too small for the smaller sizes, and therefore $\tfrac{1}{8}''$ is added. It is evident that the larger the bolt, the less importance this $\tfrac{1}{8}''$ will have, and beyond the $3''$ size it would be ridiculous to add it—nay, with still increasing bolt diameters one would go below $1\tfrac{1}{2}\,d$.

The empirical formulas for dimensions of machine parts most commonly have the same form as that for the nut diameter just mentioned, or generally the form:

$$y = px + q,$$

which means that y, the dimension sought, is not simply proportional to the given one x, but a constant q must be added to it. The manner in which the factor p and the constant q are determined in our example will be explained in connection with the section AB of our press frames of different throat depths and equal power.

We will assume that the sections (a) and (b), Fig. 1, are given as the smallest and largest size established by the tentative method, and that the designer is required to establish empirical formulas for the dimensions of the intermediate sizes, without regard to the underlying conditions, such as we have previously been taking into account in finding the dimensions. To do this, he lays out the small and large section to the same scale, their center lines distant from a fixed point O $12''$ and $60''$, respectively, as in Fig. 1. Now he draws, through the corresponding points A and A', a line intersecting the base line OX at Z. The corresponding points of the intermediate sizes, for instance A'', that of $42''$ throat, are then supposed to lie on this line ZAA'. From the geometry of Fig. 1, and with reference to the notations there used, the following equations are easily established:

$$n : x = q : m;$$

$$y = n + q;$$

from which $$y = \frac{q}{m}x + q.$$

If we call $\frac{q}{m} = p$, we get the typical formula referred to above,

$$y = px + q,$$

in which q = distance that is cut off from the vertical OY by the line ZA', and p = ratio between that distance and the horizontal distance between the point O and the *pole* Z. Suppose that by scale,

$$q = 24.5,$$
$$m = 54.25,$$
$$p = .45;$$

then the total height of the section

$$h_o = .45t + 24.5''.$$

In the same manner, empirical formulas can be set up for the other dimensions. Thus, for the dimension h, the pole Z_2 would be found and the corresponding formula

$$h = .16 + 7''.$$

When all or a number of the poles fall close together, the one located at an average distance from the zero point of the scale is selected and used as *the* pole of a so-called proportional chart. One of the principal dimensions of the design is then taken as a *unit*, and the others made directly proportional to it. This method is a most convenient one for laying out various sizes from a given design, as it requires only the location of the pole, from which vectors are drawn to the various points of the design. The corresponding points of the reduced size are then located on these vectors. Thus, suppose that for a number of existing simple bearings, as the one shown in Fig. 2, a pole Z was chosen; then, the reduced sizes can be directly laid out as shown in dotted lines in the figure. The formula for the unit is evidently of the form

$$u = px + q;$$

while those for the other dimensions are of the form $y = fu.$

When we said that the proportional chart affords a convenient means to the draftsman for laying out the dimensions of a line of designs, we did not mean to recommend the system, except in cases where close calculation of dimensions is unnecessary, as with the detail in Fig. 2, for instance. An examination of Fig. 1, in which the middle or original section $A\,B$, belonging to the 42″ press, is also laid out by the tentative method, will show that its point A_1'' falls considerably beyond that point A'' found by the pole method. For such cases, the dimensions being most important ones, the proportional chart is hardly admissible. It may be conveniently used, however, in establishing dimensions that are to be changed, checked, and verified afterwards. For all such preliminary drafting work, the writer uses cross-section paper, with great success in respect to the saving of time. The squares of the paper should for such work be divided into tenths of an inch. For final detailing, it is also often convenient to use cross-section paper, but in that case the division of the squares into eighths or sixteenths of an inch is preferable.

THE LAWS OF THERMODYNAMICS.

George A. Goodenough.

TRANSFORMATION OF HEAT INTO WORK—THE HYDRAULIC ANALOGY—CARNOT'S PRINCIPLE. LIMITATIONS IMPOSED BY THE SECOND LAW.

THE idea of using liquid air as an agent for the production of power has called forth a great deal of comment from engineers and physicists; and the so-called *second law* of thermodynamics, which has hitherto been kept in modest retirement, is now thrust into prominence and made to combat the extravagant claims of the liquid-air advocates.

In his recent article, "Magazine Science," Mr. Risteen justly calls attention to the necessity of popularizing this law for the benefit of would-be inventors of heat motors, and threatens to write a book on the subject if no one else volunteers. The task of writing this book we will leave to Mr. Risteen, believing that he is peculiarly qualified for it. We shall, however, in this short article, attempt to give some suggestions regarding the essential nature of this law and show how it applies to the transformation of heat into work.

It will be necessary first to state briefly the first law of thermodynamics: *Heat is a form of energy, a definite amount of heat being equivalent to a definite amount of work.* This law has been verified again and again. By actual measurement Hirn showed that the heat rejected by a steam engine to the condenser is less than that brought into the engine cylinder by the steam, the difference having been transformed into the work required to drive the piston. Joule, by numerous experiments, determined the numerical ratio between the heat unit and the work unit. Taking for the unit of heat the heat required to raise the temperature of one pound of water from 62° F. to 63° F., and for the unit of work, the foot-pound, or the work required to raise a weight of one pound a distance of one foot, then it is found that one heat unit is equivalent to 778 foot-pounds. The first law, then, merely asserts the possibility of transforming heat into work, or vice versa.

The question now arises, assuming that heat may be changed to work, can all the heat contained in a body be thus changed?

If not, what part of it can be transformed into work? It is in answer to this question that we meet with the application of the second law. First, however, what is meant by "all the heat contained in a body"? To give a satisfactory answer to this question, we must touch for a moment on the nature of heat.

It is supposed—and the supposition is well founded—that all bodies are composed of millions of minute particles called molecules, which are continually moving with a high velocity; and it is now well established that it is this agitation of the molecules that constitutes the phenomenon we call heat. The more rapid the motion of the molecules, the hotter the body, the higher its temperature. The energy of the vibration of the molecules is measured by the temperature of the body; and for any given body, the temperature measures the actual quantity of heat contained in the body. For example, take, for the body, one pound of air. At a temperature of 100° F. this air contains more heat than it does at 40° F., the difference being the difference in temperature multiplied by a coefficient called the *specific heat*, which for air is .2375, provided the air remains at constant pressure. If the pound of air is kept at the same pressure, an abstraction of heat is accompanied by a lowering of the temperature; hence, so long as we are able to lower the temperature, the air must still contain heat. At 0° F., for example, the air is cold as far as our sensations of heat and cold are concerned; but we know very well that we can cool this air to 10°, 50°, or even 100° below zero, which shows that air at 0° still contains considerable heat. Following the idea that heat consists in molecular motion, we arrive at the conception that a body or quantity of matter entirely deprived of heat is one whose molecules have become motionless. As we lower the temperature of the body, the pound of air, for instance, the molecules move more slowly, and it is not difficult to conceive a temperature at which motion entirely ceases. This temperature is called the *absolute zero*. The experiments of Joule and Thomson give as the absolute zero of temperature 460.66 below the Fahrenheit zero. We may mention for the sake of strict accuracy that this temperature is measured on the ideal thermodynamic scale, not on the scale of the mercury or the air thermometer. Temperatures measured from the absolute zero are called absolute temperatures.

It appears, therefore, that to change all the heat contained in a body into work, the temperature of the body must be reduced to the absolute zero. Suppose that a given quantity of some substance, say one pound of air, contains a quantity of heat which we will denote by Q_1 at an absolute temperature T_1. By some device, as an engine, this pound of air is made to go through a series of processes during which it gives up some of its heat. Let the heat remaining in the air as it is discharged from the engine be denoted by Q_2, and suppose the absolute temperature to be T_2. If there are no heat losses it is evident that $Q_1 - Q_2$ heat units have been changed into work; and the ratio of the heat transformed to the total heat Q_1 is given by the expression $\frac{Q_1 - Q_2}{Q_1}$. Now, it can be shown from the properties of gases that the following relation exists between the quantities of heat Q_1 and Q_2 and the absolute temperatures T_1 and T_2: $Q_1 : Q_2 = T_1 : T_2$, or $\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$. By means of this relation the ratio $\frac{Q_1 - Q_2}{Q_1}$ may be replaced by the equal ratio $\frac{T_1 - T_2}{T_1}$.

The preceding statements may be somewhat extended. Suppose we have an engine which receives heat from some source, as a steam boiler, at a temperature T_1 and gives up heat, as to the condenser, at a temperature T_2. Then, under the most favorable conditions possible, the ratio of the heat transformed into work to the total heat delivered to the engine, is given by the expression $\frac{T_1 - T_2}{T_1}$. If Q_1 is the heat delivered to the engine in a given time, $Q_1 \times \frac{T_1 - T_2}{T_1} = \frac{Q_1}{T_1} (T_1 - T_2)$ is the heat transformed into work, and $Q_1 \frac{T_2}{T_1}$ is the heat rejected by the engine.

The transformation of heat into work may be advantageously illustrated by a hydraulic analogy. Suppose we consider the level of the sea as analogous to the absolute zero of temperature; and suppose we have water at a height h_1 above the sea level falling to a height h_2 above this level. If W denotes the weight of the quantity of water, then the total work that can be done by this water in falling from the height h_1 to the sea level is given by the product $W h_1$; the work that can be done when W falls from the height h_1 to the height h_2 is $W(h_1 - h_2)$. Evidently, the

ratio of the work done to the total work that could be done if the total fall to the sea level could be utilized is $W(h_1 - h_2) \div Wh_1 = \frac{h_1 - h_2}{h_1}$. This corresponds to the ratio $\frac{T_1 - T_2}{T_1}$, the temperature fall in the heat engine being analogous to the water fall that drives the waterwheel. In connection with this hydraulic analogy, it is interesting to note Carnot's interpretation. Carnot, in common with nearly all scientists of his time, believed heat to be a material substance, which could not be destroyed; hence, he reasoned that the quantity of heat Q_2 rejected by the engine must be equal to the quantity Q_1 entering the engine, just as the weight of water emerging from a waterwheel is equal to the weight of that entering. The work done by the heat, he reasoned, was due to the fall of temperature, and must be given by the expression $Q_1(T_1 - T_2)$, just as the work of the falling water is given by $W(h_1 - h_2)$. We know now, however, that the heat rejected at the lower temperature is *less* than that received at the higher temperature. Since heat is a form of energy, Q_1 must be analogous to Wh_1, the potential energy of the water at the upper level; and Q_2, in a similar manner, is analogous to Wh_2. As we have shown, the maximum heat that can be transformed into work is $\frac{Q_1}{T_1}(T_1 - T_2)$; hence, since the temperature fall $T_1 - T_2$ is analogous to the fall $h_1 - h_2$, the quotient $\frac{Q_1}{T_1}$ must be analogous to the weight W of the water, instead of the heat Q_1, as stated by Carnot. For this reason the quotient $\frac{Q_1}{T_1}$ is sometimes called the *heat weight.*

If, now, we investigate the conditions that must obtain in order that a waterwheel may utilize all of the available work $W(h_1 - h_2)$, we may be able to indicate the conditions required for a heat engine to utilize the available energy $\frac{Q}{T_1}(T_1 - T_2)$. In the first place, the water must all be taken in at the level h_1 and discharged at the level h_2. For, suppose that the flow of water should reduce the upper level from h_1 to h_1'; then the average upper level would be $\frac{1}{2}(h_1 + h_1')$, which is lower than h_1; therefore, the fall is lowered and the available work is decreased. Secondly, none of the water may be spilled or lost during the fall. The analogous conditions for the heat engine are: (1) The working fluid must absorb the heat Q_1 at the constant temperature T_1 and must reject the heat Q_2 at the constant temperature T_2. (2) While the temperature of the fluid is falling from T_1 to T_2 no heat may be spilled or lost.

The next point to be considered is the reversibility of the processes just described. Suppose that instead of having the water do work in turning the waterwheel, we provide the work $W(h_1 - h_2)$ from some external source and turn the wheel backwards. It is evident that theoretically the wheel will take the water W from the lower level h_2 and restore it to the upper level h_1. Similarly, a perfect heat engine will work backwards. In the reverse process it takes the quantity of heat from the colder body at a temperature T_2, adds to it an amount of heat equivalent to the work of the engine, and delivers the sum to the hotter body at a temperature T_1. We have actual examples of these reversed heat engines in the compression refrigerating machines so largely used at the present time.

We are now in a position to state Carnot's principle, which is the basis of the second law of thermodyamics. It is as follows: If a given reversible heat engine, working between the temperatures T_1 and T_2, receives a quantity of heat Q_1 at the upper temperature, and produces a quantity of mechanical work, then no other engine, whatever be its construction, can produce a greater quantity of work, when supplied with the same quantity of heat, and working between the same temperatures. From this it follows that all reversible engines working between the same temperatures transform the same percentage of the heat supplied into useful work; that is, all reversible engines working between the same temperatures have the same efficiency. It also follows that the efficiency of the engine depends in no way upon the properties of the substance used for a working fluid, but only upon the higher temperature and the range of temperature.

The reasoning that establishes Carnot's principle is simple, especially when the principle is applied to our ideal reversible waterwheel. Suppose we imagine a waterwheel more efficient than the one we have described—one that will do *more* work than $W(h_1 - h_2)$ when supplied with the weight W of water and working with the fall $h_1 - h_2$. Evidently, then, this device will do the work $W(h_1 - h_2)$ with a *less* weight of water than W, which weight we may denote by W'. Suppose these wheels are coupled together

so that the second runs direct while the first runs backwards. The direct-acting wheel takes the water W' from the upper level and delivers it to the lower level, the work done by the water on its wheel being, according to our supposition, $W(h_1 - h_2)$. This work is delivered to the reversed wheel, and, as we have seen, will cause that wheel to take the water W from the lower level and deliver it to the higher level. It appears, therefore, that the combined wheels take the water W' from the upper level and restore the water W to the same level; that is, at each operation the water $W - W'$ is raised from the lower to the higher level. We have, therefore, a self-acting machine, which will raise water from a lower to a higher level. Applying the same reasoning to the heat engine, it is seen that if any engine could have a greater efficiency than the ideal reversible engine, then we should have a self-acting device that would transfer heat from a colder to a hotter body.

It is contrary to our experience that water can without assistance pass from a lower to a higher level, that is, flow up hill, or that heat will, unassisted, flow from a colder to a hotter body. If we assert that heat cannot be conveyed from a colder to a hotter body without the expenditure of some energy to effect the transfer, it follows that no heat engine can be more efficient than the ideal reversible engine. This assertion, based on experience, is usually given as the second law. The exact statement as given by Clausius is as follows: "*It is impossible for a self-acting machine, unaided by any external agency, to convey heat from one body to another at a higher temperature.*" For some purposes the following statement of the law by Maxwell is preferable: "*It is impossible by the unaided action of natural processes to transform any part of the heat of a body into mechanical work except by allowing heat to pass from that body into another at a lower temperature.*"

The second law imposes a decided limitation upon the transformation of heat into work. We have unlimited supplies of heat in the atmosphere that surrounds us; and it may seem feasible at first sight to get any amount of energy we require simply by transforming the heat of the atmosphere into work. The second law teaches us, however, that before we can make this transformation, we must obtain either naturally or artificially a difference of temperature. If we use the atmosphere as a reservoir from which to draw heat, we must have some other substance permanently colder than the atmosphere to which we may reject the portion of the heat that is not transformed. Now, there is a constant tendency towards the equalization of temperature, and it is not possible to find ready at hand any body colder than the atmosphere; even if we should find such a body, the heat rejected to it would very soon raise its temperature to that of the atmosphere, thus destroying the temperature fall and stopping the change of heat into work. We may accept the conclusion that we are not likely to find a natural available temperature fall, and that we must create one artificially. It is here that our hydraulic analogy fails; for we can obtain a natural water fall.

LIQUID HYDROGEN.

J. T. Beard.

WHAT may be called the sister discovery to that of liquefying air is the reduction of hydrogen to the state of a liquid. This has at last been successfully performed by Professor Dewar, of the Royal Institute, London. The amount produced was about two fluid ounces. This rare liquid was found to boil at 432° F. below zero, which is the nearest approach ever made to the absolute zero of the thermometer scale. The density was found to be .6 as referred to water. The liquid in passing into the gaseous state is capable of over 7,000 expansions, thus producing a ruptive pressure, if confined, of over 50 tons per square inch. Perhaps, one of the most important uses, from an industrial point of view, to which these rare liquids may eventually be applied will be found in their application, as high explosives, to conditions where detonators are dangerous, either on account of the shock incident to handling, or from the environment of a gaseous atmosphere. Such a use has already been suggested for liquefied air in gaseous mine workings. A new and wide field for the exercise of inventive talent in the discovery of other uses for these liquids is thus opened.

A GREAT DISCOVERY.

George McC. Robson, M. A.

THE TRUE SCIENTIFIC METHOD—FIRST ENGLISHMAN OF SCIENCE—THE CARTESIAN VORTICES. NEWTON'S EARLY LIFE.

Of old sat Knowledge on the heights,
The thunders breaking at her feet:
Above her shook the starry lights;
She heard the torrents meet.

There in her place she did rejoice,
Self-gathered in her prophet-mind,
But fragments of her mighty voice
Came rolling on the wind.

Then stept she down through town and field
To mingle with the human race,
And part by part to men reveal'd
The fulness of her face.

—*Altered from Tennyson.*

Many persons regard the secrets of nature as conundrums to be guessed in some moment of idle speculation, and are firmly persuaded that many of the greatest discoverers owe their discoveries to the inspiration of some trivial accident. This view is strongly supported by the superficial accounts that some popular writers have given of Newton's discovery of the law of universal gravitation; these writers, endeavoring to make an interesting and eventful narrative with a useful moral, have expended much ingenious rhetoric in decorating the tradition that the fall of an apple first suggested to Newton the idea that the force which retains the moon in her orbit is the same as terrestrial gravity, and unlimited amazement is expressed that the simple fall of an apple should have led to the discovery of the laws of the universe. The story of the apple is pleasant and plausible, and this account of the discovery of the law of gravitation is easy both to write and to read; it is defective, however, in that it does not, in the least, help one to understand how Newton made his discovery or what it was that he discovered. The fact is that various writings, well known to Newton, gave more suggestion of gravity extending to the heavenly bodies than all the apples ever harvested in England could have done. A long list of quotations from, and references to, these writings is given in the preface to a treatise on Astronomy, published in 1702, by David Gregory, Savilian professor of astronomy in the University of Oxford; this work was very highly commended by Newton, and the quotations from ancient authorities that are given in the preface are abridged from notes supplied to Gregory by Newton in his own handwriting. It appears, then, that the apple, even if it be not altogether apocryphal, was not the most potent factor in the genesis of Newton's great discovery; and it is manifestly impossible to tell the story of his discovery without indicating, however briefly, the steps that led up to it, and referring to a few of the great men who anticipated to some extent the methods Newton employed.

SIR ISAAC NEWTON.

Roger Bacon, the first Englishman of science, was born at Ilchester in 1214 and died at Oxford in 1294. In his *Opus Majus* we find the first clear enunciation of the method that Newton used so successfully. Bacon laid down the fundamental principle that there can be no knowledge of nature without observation and experiment; and he explained in detail how every natural science must be based on mathematics, and can make progress only

when its fundamental principles are expressed in mathematical form. These views are in close accord with the best modern ideas, and foreshadow very clearly the methods used by Newton; but they were so far in advance of Bacon's age that they were utterly incomprehensible to his contemporaries.

A more successful advocate of the employ-

WOOLSTHORPE MANOR.

ment of mathematics in scientific research was the brilliant French philosopher René Descartes, who was born near Tours on March 31, 1596. He pointed out that geometers, starting with a few self-evident axioms, were able to deduce the most abstruse propositions from those axioms by a vigorous process of reasoning, and maintained that in a similar manner the mysteries of the universe could be solved by mathematical reasoning based on a few fundamental principles. This is but a partial statement of the true method, for Descartes fails to emphasize, as Bacon did, the necessity of frequent appeals to observation and experiment to verify the results of the reasoning; to this contempt for experimental verification is to be ascribed the failure of Descartes's attempt to explain physical phenomena.

Descartes says science is a tree of which metaphysics is the root, physics is the trunk, and the three branches are mechanics, medicine, and morals; these branches being the applications of our knowledge to external affairs, to the human body, and to the conduct of life. In 1644 he published his *Principia Philosophiæ* ("Principles of Philosophy"), which deals chiefly with physical science and in which he treats of the laws of motion and the theory of vortices. Descartes's philosophy was long dominant in Europe; it was taught in all the universities, Newton himself was brought up in this faith, and for a time the vortex theory maintained itself as a rival of the Newtonian theory of universal gravitation; it is, therefore, germane to our purpose to give a slight account of Descartes's vortices. In his *Principia*, Descartes attempts to construct a system of philosophy that is absolutely free from assumptions; accordingly he begins with an attempt to demonstrate his own existence; this he conceives to be proved by his famous aphorism, "I think, therefore I exist." This is the starting point of his system; he then asserts that it is manifestly impossible that a vacuum can exist anywhere, and maintains that the universe is a *plenum*, "filled with matter." Originally this matter consisted of equal parts with sharp corners; by the motion of the parts, their corners are rubbed off till the parts are reduced to spherical form, and the dust produced by the abrasion constitutes another and subtler form of matter. There is also a third form of matter—the material of which the earth and all opaque bodies are composed. Luminous bodies, like the sun, are composed of the first kind of matter, the transparent interplanetary spaces are filled with the second kind of matter. All this matter is revolving in circular currents, or whirlpools, which are called vortices. The first kind of matter naturally collects together at the center of each vortex, the second kind of matter forms an all-pervading medium surrounding the center. Thus he accounts for the fact that the sun is the center of the solar system; to explain the motion of the planets, each planet has a special vortex in which it is whirled round like a straw in the eddy of a swift-flowing stream. Gravitation is attributed to the settling down of bodies toward the center of each vortex.

SUN DIAL FROM WOOLSTHORPE MANOR.

It is easy to show that Descartes's vortex theory is full of inconsistencies, and that the consequences deduced from it by logical reasoning are incompatible with well-known and indisputable facts. Yet it found ready acceptance among intelligent men and good mathematicians, because it filled the void left in men's minds by the overthrow of the Ptolemaic system. Kepler had established

his three laws as facts, but the human mind is never satisfied with the knowledge of a fact but ever seeks to know why the fact is so and not otherwise; Kepler himself sought for the explanation of his laws, and with wonderful prophetic instinct spoke confidently of a physical astronomy that would give a rational explanation of his laws. Descartes's *Principia*, then, appeared at a time when men's minds, shaken from the old faith, were willing to accept any plausible theory that afforded them even a temporary resting place, and most of the adherents of the vortex theory accepted it without much investigation; indeed, it is well known that the number of those who had the courage to read Descartes's *Principia* through was very limited.

Though the Cartesian vortices have long since been discarded, it would be unsafe to regard his theory as altogether absurd. The leaders of thought today are agreed that all space is filled with a medium capable of vortex motion, and some physicists are endeavoring to show that rigidity and all the other properties of matter are due to vortices in this medium; but, whereas Descartes's vortices were very large, the modern physicist prefers vortices of infinitesimal dimensions. However, without attributing any inherent absurdity to the Cartesian philosophy, it is necessary to point out that it was not in any sense an anticipation of, or a step toward, Newton's discovery. Newton, it is said, read only about eight pages of Descartes's *Principia*, and on those pages he wrote the word "error" several times. This sketch of the vortex theory shows, what can also be shown from the writings of other authors, that inquiring minds were then eager to discover the deeper laws of which those of Kepler were but the outward expression and consequence.

Descartes's greatest service to science, however, was not his physical theories, but his invention of the method of Analytical Geometry. This is a genuine invention of the highest merit, and is a powerful and indispensable instrument in scientific investigations. Newton's discoveries could not have been made without the aid of the Cartesian geometry, and if Descartes had not invented it Newton would have had to spend some of his valuable time in working out some similar system himself. Moreover, the Cartesian geometry led directly to the invention of the Differential Calculus by Newton and by Leibnitz.

But the real foundation on which Newton erected his stately edifice was discovered by Galileo. In the last years of Galileo's life, when he was blind and helpless, he reasoned out the fundamental laws of motion on which the whole modern science of mechanics rests. These laws are sometimes called Newton's laws of motion, because Newton stated them in the following form:

1. *Every body continues in its state of rest or of uniform motion in a straight line, except in so far as it is compelled by forces to change that state.*

2. *The change of the quantity of motion is proportional to the force that causes the change, and takes place in the direction in which the force acts.*

In this law the quantity of motion of a body means the product of its mass and its velocity.

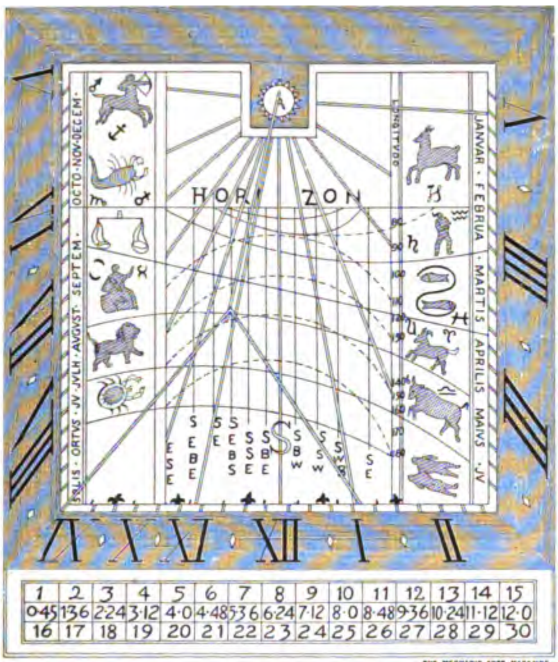
3. *To every action there is always an equal and opposite reaction; or the mutual actions of two bodies are always equal and oppositely directed in the same straight line.*

The laws of motion are the fundamental principles of mechanics, and when these laws are properly expressed in mathematical language there can be derived from them, by purely mathematical reasoning, a vast and orderly store of knowledge. Descartes unfortunately never understood the laws of motion, therefore the first principles from which he started were wrong, and no amount of correct reasoning from false premises could lead him to correct results. Had he condescended to verify his results by experiment, he might have detected his errors, retraced his steps, and amended his first principles. It may be said that Galileo laid the solid foundation on which Newton built, and Descartes invented some of the tools that Newton used in building.

The discovery of the laws of motion was perhaps Galileo's greatest contribution to science, and formed a fitting close to his remarkable life. On January 8, 1642, the veteran Galileo died, and before the close of that year there was born in England a sickly infant who was destined to carry on gloriously the work so nobly begun by Galileo.

Isaac Newton was born, to a widowed mother, in the manor house of Woolsthorpe, near Grantham, in Lincolnshire, on Christmas day, 1642. His father, who was a yeoman farmer, died a few months after his marriage with Harriet Ayscough, and very little is known of him. The care of the delicate infant and of the farm both devolved upon Mrs. Newton, who was eminently sensible

and practical, and in every way a most excellent woman. Mrs. Newton was afterwards married to the Rev. Barnabas Smith, to whom a parishioner had recommended "the widow Newton as a most extraordinarily good woman." On her second marriage she went to live at North Witham, and her mother, Mrs. Ayscough, came to Woolsthorpe to take charge of Newton. After attending the village school for some time, Newton was sent to the grammar school at Grantham, which he attended for three years, during which time he boarded at the house of Mr. Clark, an apothecary. At first, Newton was neither a diligent nor a successful student; Latin grammar apparently had no charms for him, and he states himself that he was the last boy in the lowest class but one. The school bully, who held the place immediately above Newton in class, one day gave Newton a severe kick in the stomach; whereupon Newton straightway fought and beat the bully. This victory aroused his ambition, and from that time he devoted himself with incessant energy to study and quickly reached the head of the school. During this period, though he did not often join his companions in play, he was a recognized leader among them, and supplied them with a variety of toys of his own construction. He was particularly skilful in making kites, waterwheels, and windmills. One of his favorite amusements was to frighten the country people by tying a paper lantern to the tail of a kite on a dark night, which the country people took for a comet foreboding war, pestilence, and famine.



SUN DIAL.

THE MECHANIC ARTS MAGAZINE.

The one love affair of Newton's life occurred while he was an inmate of Mr. Clark's household. He appears to have fallen in love with Miss Storey, who also boarded with Mr. Clark's family. She was two years younger than Newton, and is said to have been a young lady of great attractions and considerable talent. Newton delighted in her society, and he presented her with several very ingeniously constructed cabinets. Poverty seems to have been the only bar to the consummation of their happiness. Miss Storey was afterwards married twice, and at the age of 82 she was Mrs. Vincent, living at Grantham. Many stories of Newton's early life were obtained from Mrs. Vincent by Dr. Stukeley. Newton's affection for her never failed; in her old age he frequently visited her and relieved her financial difficulties by generous aid.

About this time Newton constructed a water clock, which was long used in Mr. Clark's family. In shape it resembled an old-fashioned house clock; the index on the dial plate was turned by a piece of wood that was set in motion by dropping water. He constructed, also, a mechanical four-wheeled carriage driven by a handle turned by the person seated in the carriage. Mrs. Vincent is the authority for the statement that Newton early displayed great talent in drawing, and excelled in poetical composition. Some of these boyish verses were remembered and repeated by Mrs. Vincent seventy years afterwards.

When Newton was fifteen years old his mother's second husband died, and she returned, with three children of the second marriage, to Woolsthorpe. Newton was taken from school to assist in the management of the farm. Part of his duty was to accompany an old servant to Grantham to

do the weekly marketing. On these occasions he left the marketing to the servant, and retired to the attic of Mr. Clark's house, where he read all the books he could find. During this period he constructed several sun dials; one of these dials was cut on a stone in the wall of his own house; this stone is preserved in the library of the Royal Society, and the letters TON are still visible on it.

Mrs. Smith, observing that her son was likely to be a very unsuccessful farmer, consulted her brother, who was rector of a neighboring parish. Her brother very wisely recommended that Newton be sent back to the school at Grantham, to prepare for entrance at Trinity College, Cambridge. At school Newton acquired a fair knowledge of Latin, which was practically the only subject then taught in English schools; he also picked up, without any assistance, some knowledge of mathematics and science, and he read some logic, which was regarded as a necessary preparation for the study of mathematics.

In 1661, Newton entered Trinity College, Cambridge, as a subsizar. During his first year of residence at the university he attempted to read a book on astrology, but could not understand it on account of the geometry and trigonometry. He therefore read in order Euclid's "Elements of Geometry," Oughtred's "Clavis" (i. e., Oughtred's key to the mathematics), and Descartes's "Geometrie." Euclid he found surprisingly easy. The Cartesian geometry he mastered by himself, though with considerable difficulty, and it fascinated him so much that he resolved to devote himself to mathematics, rather than to chemistry, as his serious study.

During his undergraduate career, Newton made two splendid discoveries in mathematics. His first great discovery was the binomial theorem, with which every student of algebra is familiar. His second great discovery was the method of fluxions, now known as differential calculus. The oldest professorship of mathematics in Cambridge University—the Lucasion—was then recently founded, and Dr. Isaac Barrow, an eminent mathematician and a very genial old man, was the first Lucasian professor. Newton rendered great assistance to Dr. Barrow in the preparation of his treatise on optics. In the preface Dr. Barrow acknowledges Newton's help, and says that Newton corrected many errors and made several valuable additions of his own. The discoveries that Newton had already made in pure mathematics and in optics, if he had never done anything more, would have been sufficient to rank him among the greatest scientific men that ever lived. He took his B. A. degree in 1665, and shortly afterwards he was driven from Cambridge by the great plague. He retired to Woolsthorpe, and the period of his residence in the home of his boyhood is crowded with brilliant discoveries.

THE GREENLAND WHALE.

Ernest K. Roden.

THE DIFFERENCE BETWEEN WHALE AND FISH—CHARACTERISTIC FEATURES OF THE GREATEST INHABITANT OF THE SEA—WHALE HUNTING AND OTHER INTERESTING MATTERS.

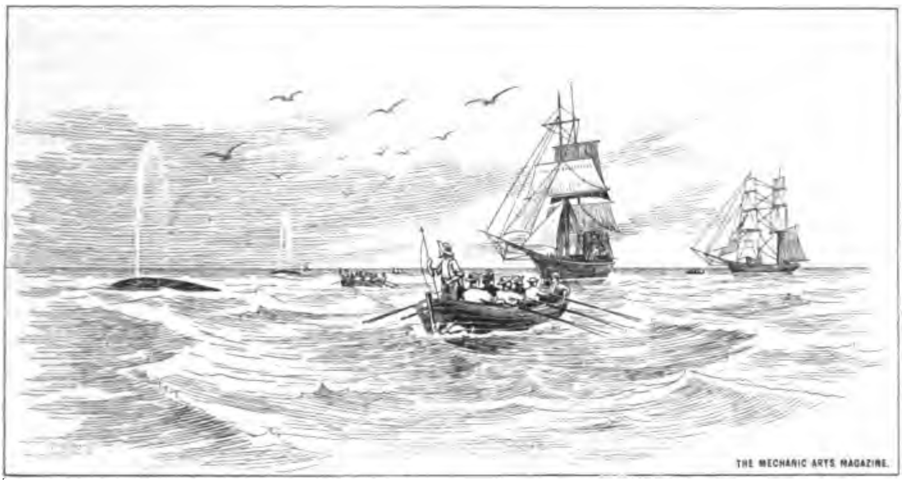
IF ASKED to describe a whale, a person having but a superficial knowledge of zoology will say that it is "a very large fish." So far as the appearance of the animal goes, the correctness of this statement cannot be disputed, but a closer study of this great inhabitant of the high seas, and especially of its internal organs, etc., will soon convince the most skeptical that the above description is wrong—that in fact the whale is not a fish at all, but belongs to the class known as *mammalia*, and forms a part of the large subkingdom to which we human beings also belong.

Let us note some of the differences between a fish and a whale. To begin with, a fish breathes by gills, obtaining the oxygen necessary for its support from the water; a whale, on the other hand, breathes by lungs, rising to the surface of the water at intervals to breathe, just as we should if similarly circumstanced. A fish is covered with scales, but a whale is not; while the blood of a fish is cold, that of the whale is warm. The most important difference, however, and one that elevates the whale to a zoological position far above that of any fish, is the fact that the offspring of the whale is born

alive and is nourished by its mother's milk. As a general rule, fishes do not enjoy the advantage of parental care, being hatched and developed from ova, apparently without attention and without any defender against their many enemies. Such is not the case with the young whale, the mother displaying for it the greatest affection and seeming to immensely enjoy the task of protecting it from danger.

Another thing that identifies the whale with the mammalia is the formation of its heart; this is double, and therefore capable of propelling the blood through the system and receiving it again. Anatomically, the whale is found in one particular, namely, the construction of the pectoral fin, to resemble man. In the human arm we find, as shown at (*b*), Fig. 1, a shoulder blade, an upper arm, a radius, an ulna, and five fingers. In the pectoral fin of the whale we find a stunted copy of this arrangement, as shown at (*a*), Fig. 1. But the arm that in man moves freely, and, in obedience to human volition and intellect, executes such miracles of industry and art, is here chained to the body as far as the hand, which latter is covered with a thick skin and appears as a broad, undivided fin, or flipper; yet it serves a higher purpose than that of a mere propelling oar, being used by the mother to guide and shield her young as well as to direct her own movements.

Of the several species of whale in existence, the most important is the Greenland whale, which inhabits the seas of the northern part of the world and abounds chiefly in the arctic regions. Its greatest length is from 60 to 70 feet, and around the thickest part it measures from 30 to 40 feet. The tail, which is very powerful and used not only as a defensive and offensive weapon but as the principal aid to locomotion, is from 5 to 6 feet long and from 20 to 25 feet broad; it is formed of two diverging lobes, broadest almost where they are united, but with a slight indentation. The pectoral fins are 8 or 9 feet long, and from 4 to 5 feet broad. The eyes, which are situated on the sides of the head about a foot above and rather behind the angles of the mouth, are no larger than those of an ox, but their sense of sight seems to be acute, at least when under water. The mouth of a Greenland whale is from 15 to 16 feet long, and instead of being provided with teeth, its enormous upper jaw is beset with about 500 laminæ of a horny substance known as *whalebone*, though in reality it is no bone at all. These laminæ are ranged side by side, about two-thirds of an inch apart, and remind one of the frame of saws in a sawmill. The lower edges of these whalebones are fringed with hair, and from the palate are suspended numerous smaller laminæ of the thickness of a quill, a few inches long and likewise terminating in a fringe of hair. Thus the whole roof of the mouth appears as a shaggy fur, below which lies the soft and spongy tongue. This whalebone covering—usually known as the baleen—is beautifully adapted to the peculiar manner in which the whale obtains his food, which he does in the following manner: He swims rapidly with open mouth,



SCENE AT A WHALING GROUND.

and gathers in as many as possible of the minute animals and fishes contained in the water; then, closing the "wide gates," he expels the water in foaming streams, but retains the little creatures, which become entangled by the thousand in the fringy thicket as though caught in a net. It is thus seen that the principal food of the whale does not consist, as one might at first suppose, of the larger fishes, but of those very small inhabitants of the sea known as *pteropod mollusks*, and also of small fishes, few of which, however, are larger than a herring; hence, the prevailing belief that the worthy, though somewhat sinful, prophet Jonah was swallowed by a whale, is but the creation of some highly imaginative mind, and is not based on fact.

The skin of a whale is about an inch thick, and covers a layer of fat 15 inches thick; this dense covering serves the animal as a great coat, and keeps its body warm in the cold seas that it inhabits. The color of this skin is usually of a fine glossy black on the upper part of the animal, while the under part and lower jaw are of a dead white.

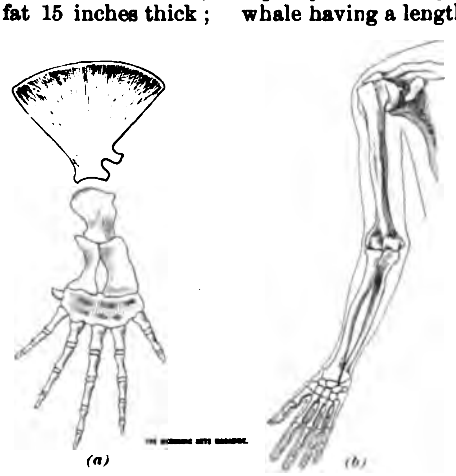


Fig. 1.

One young whale is produced at a birth, and is then from 10 to 14 feet in length. Suckling is performed at the surface, the mother rolling from side to side in order that she and the young one may be able to breathe in turn. Whales generally come to the surface to breathe at intervals of from 8 to 10 minutes, but they are capable of remaining under water for half an hour or more; when they do come up they usually remain on the surface for 2 or 3 minutes, during which time they blow out a certain amount of water through the air hole situated on the top of the head, and then descend. The noise they make in blowing is very loud, and the spout of spray ejected ascends several yards into the air, appearing at a distance like a puff of smoke. In its sportive humors the whale is sometimes seen to spring out of the water, and to remain suspended in the air for a moment. On falling back, high foam-crested fountains spout forth on all sides. At other times it raises its head vertically out of the water, so that the lookout on some ship in the vicinity fancies he sees a black rock looming up in the distance. Quite suddenly, however, the fancied rock turns over and round, and brandishes playfully its enormous flukes in the air, or lashes the water with such prodigious power that the noise is distinctly heard 2 or 3 miles away, and resembles thunder rolling over the deserts of the ocean. As to the speed developed by whales, nothing definitely can be said; their average march through or at the surface of the water is estimated to be at a speed of about 4 miles an hour, but this is greatly increased if the animal is frightened—something that easily happens—and when wounded, terror and pain drive it through the water with astonishing rapidity. The weight of a well-nourished whale having a length of 60 feet is, according to Scoresby, 70 tons. Of this vast weight the blubber, or coat, accounts for 30 tons, the bones 10 tons, and the rest of the carcass the remaining 30 tons.

That whales enjoy the benefit of good sound sleep is evidenced by the fact that ships sometimes collide with them as they rest unconsciously slumbering at the surface of the water. Not very long ago the copper sheathing on the bow of the Danish sailing ship "Harold" was damaged to some extent by colliding, in the dark of night, with a sleeping whale. The crew believing the ship to be sinking, from having run against some unknown hidden rock, began sounding the pumps and clearing the life boats. No water, however, was found in the hold; and when daylight broke a close investigation of the bow showed lumps of a greasy substance jammed between pieces of the torn sheathing, which proved beyond doubt the nature of the "rock" encountered. Presumably, a considerable time will elapse ere that particular whale is again caught napping.

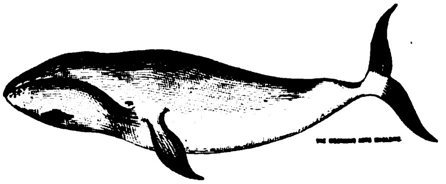
Whale hunting, that is, the capturing and killing of the whale for the purpose of utilizing the valuable oil and other useful substances contained in its body, has been practiced for centuries. It is not only a very

dangerous and laborious pursuit, but it is also extremely precarious and uncertain in its result. Sometimes a complete cargo of oil and whalebone is captured in a comparatively short time, but it frequently happens that a "whaler," as a vessel engaged in whale hunting is called, may cruise for months without getting a single whale.

The method of whale catching has been so often and so minutely described that it is possibly familiar to the reader. However, for those not acquainted with the methods employed a brief description may be of interest.

Each whaler has generally six or seven boats, from 25 to 30 feet long, each capable of carrying six or seven men, together with a sufficient amount of whale line. The crew of a whaler consists of from 40 to 50 men, each of whom, from the captain down to the boys, receives, in addition to his regular salary, a gratuity for every whale caught, and a certain sum for every ton of oil produced from the cargo. When the ship arrives in the vicinity of a whaling ground, or a region of the sea frequented by whales, a lookout is stationed at the foremast head, and as soon as a whale is sighted the boats are lowered and manned. A regular race between the boats is now usually indulged in, each boat crew exerting their utmost strength to reach the whale first. The harpooner—one of the crew, a man of unflinching eye and nerve—is ready, as soon as the boat is sufficiently near the whale, to hurl his harpoon into the animal's side with all his strength; the men at the oars instantly back the boat, and the whale when struck usually dives down perpendicularly with fearful velocity, sometimes carrying out more than 200 fathoms of the line attached to the harpoon. It remains below for about 20 minutes or more, and when it rises the boat hastens towards it again, and a second harpoon is planted in its body. Now, instead of at once descending, it usually strikes violently with its tail, to destroy its enemies; at such times great caution is necessary on the part of the boat's crew, since a single blow from its powerful weapon, the tail, will smash the boat to pieces and send its occupants into eternity in short order. When again descending it cannot remain long below, and returning to the surface it usually spouts blood through the blowhole and lashes the crimsoned waters into foam. Lances are then used by the boats to make the struggle short; when lanced it sometimes dies almost at once, but sometimes a terrific battle takes place. Not unfrequently it happens that, instead of dying at the surface of the water, the whale descends and does not appear again, and is consequently lost.

When floating inert and lifeless, it is towed by the boats alongside the ship, and made fast to its side by hawsers and chains. The



THE GREENLAND WHALE.

process of *flensing* then begins. Several of the crew, having their boots armed with iron spikes to prevent slipping, descend upon the carcass and cut into the blubber, removing long strips of skin, which are hoisted to the deck. The skin removed, great cubical pieces of blubber, of from a thousand pounds to a ton in weight, are cut out and brought on deck. In this way the flensing is carried on, the whale being turned over and over, in order that every part may be reached.

Meanwhile, others of the crew, having opened the mouth of the dead whale, enter it and remove the baleen. What is left of the carcass is then flung adrift, and sometimes it sinks, but oftener floats. In the latter case, a magnificent feast for birds and fishes begins, they having assembled in the vicinity when the flensing commenced, attracted by the odor and unusual scene, and with difficulty being kept at bay by the men while the work was going on. Crowds of fulmars and snowbirds now flock together and enjoy, side by side, the delicious repast. But, on earth perfect felicity is rare, and so with their delight, which is often disturbed by the appearance of their dreaded enemy, the blue gull, which surpasses them in strength, and frequently forces them to disgorge the daintiest morsels. At the same time, sharks and other inhabitants of the deep that are by nature provided with powerful teeth, are busy biting and cutting that part of the carcass which is below the water-line. As a consequence of this elaborate feast, which sometimes lasts for days, the carcass, being deprived of its floating material, finally disappears.

Meanwhile the crew of the whaler is busy, paying no attention to the rather noisy diners. The blubber, after being received on deck, is cut into smaller cubical pieces and subjected at leisure to a process by

which the cellular tissue is separated from it; the product is finally stored in casks, to be conveyed home and boiled for oil. From a ton of blubber is produced nearly 200 gallons of oil, and a single whale yields blubber and whalebone of a value ranging from $3,500 to $4,000.

The harpoon used in whaling consists in its simplest form of an iron spear, about 5 feet in length, with a well-flattened point, having sharp cutting edges and two large barbs. The gun harpoon is similarly shaped and is fired from a small swivel cannon attached to the whaler's boat.

Of late, several other methods have been introduced in the whale-killing business, some of which have met with favor while others have not. Among the latter is the introduction of deadly poison into the body of the whale by means of a harpoon constructed for that special purpose; the crews of the whalers, however, objected strongly to work on the carcass and handle the blubber from a whale killed by poison. Electricity may, however, in the future, take a prominent place in the whale-killing business.

Another method of despatching the whale, which is peculiar and interesting, is practiced in the fiords of Norway. When a whale finds its way through a narrow inlet of one of these fiords it often fails to recognize the passage when trying to get out again. The inhabitants then are all on the alert to compass his destruction, and this they generally do without the smallest risk to themselves. They shoot an arrow high in the air so that when it descends it will, if properly aimed, bury itself in the back of the whale. The arrow is a short piece of iron, and the older and rustier it is, the better it fulfils its purpose. The arrow works itself down through the flesh to some vital part, or makes a poisoned wound that soon brings the whale to the surface, dead. A loose wooden shaft is fastened to the iron dart, and marks on this shaft indicate to whom it belongs, and, consequently, no dispute can arise as to the dealer of the fatal blow.

Important as the whale is to the cultured man for the oil and whalebone that it yields—the latter being used principally as stiffening in dress bodices, and for fans, etc.—it is of no less importance to the rude native of those shores washed by the Arctic Ocean. The Eskimo and Greenlander uses it for food as well as for fuel; its flesh is their chief article of food, while its bones and baleen are used for making tents, boats, harpoons, spears, and sledges; the sinews supply a substitute for thread, and the membranes serve as window glass.

As to the age of whales much speculation has arisen, but nothing definite can be stated. Some naturalists claim eight or nine centuries to be the average period of the whale's wanderings in this world—this supposition being based on certain peculiarities displayed by the animal—while others consider this age entirely too great. Whatever the exact age, the whale's existence is, like our own, a mixture of joy and sorrow.

Besides man, it has a vast number of enemies, the most dangerous of which are the swordfish and the Greenland shark, that often attack him conjointly and in packs. Fishermen relate that whenever the whale and swordfish meet, they engage in deadly combat, the latter invariably making the attack with inconceivable fury, the engagement ending only with the death of one of the unwieldy combatants. Besides these attacks of what may be termed more or less noble foes, the whale is constantly harassed by several insects that bite and inflict upon its body painful wounds. The whale lice are the principal offenders belonging to the latter category. They adhere to the back of the whale by the thousand, making it their feeding ground, sometimes turning it into one vast sore. In addition, barnacles often cover the whale in such masses as to make its skin appear to be clothed with a large whitish robe, and in the summer, when the plague is greatest, numerous sea birds accompany the whale and settle on its back as soon as it appears at the surface, in order to feed upon these disgusting parasites.

So, after all, we may conclude that the life of this noble monarch of the ocean is not altogether an enviable one.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Fate of Finland.

JUST one year has elapsed since the Emperor of Russia invited the world powers to assemble in what is now commonly called the Peace Conference. The proposition was received with enthusiasm by Great Britain, who generally has a "little war" on her hands; with moderate interest by the United States, then at war after thirty years of peace; with manifest irritation by France, who does not intend to sheathe her sword until her old frontier is restored to her; with cautious curiosity by Germany, doubtful of the intentions of her neighbor and jealous of imperial prerogative; and with more or less indifference by the other powers, who, however, agreed to accept the Czar's invitation and send representatives to the conference.

It is quite natural that the English-speaking nations, who show a keener interest in the objects which the Russian government professed to have at heart, should also have observed more keenly than usual the affairs of Russia during the past twelve months. And this for two reasons. Russia, as represented by her Czar and his ministers, rarely tells anything about herself unnecessarily; she is an adept in the art of holding her tongue. The nations to whom a general war would be a great calamity feel a friendly curiosity about the neighbor who comes forward as the advocate of peace. They remember also that "deeds, not words," are the best evidence of character. They desire to infer from her present actions the degree of confidence which may be placed in Russia's promises for the future. Her past history is that of an aggressive rather than a peaceful power, enlarging her borders every year, and so protecting a frontier (which no one has ever threatened) that counter-defenses have become necessary; while she employs in her diplomacy the oriental rather than the western standard of truthfulness. Peace between men or between nations can only be secured by fairness, by uprightness, by just dealing, by mutual respect for one another's rights. Has Russia turned over a new leaf? Has the Ethiopian changed his skin, or the leopard his spots? Ask the students of St. Petersburg; let China—let Finland answer!

A year ago a paragraph headed "Russia and Finland" would have attracted very little attention among English-speaking people; now newspapers and magazines alike devote space to a statement of the case. A country smaller than California, situated in a remote part of Europe, and with a population less than half that of Pennsylvania, Finland has been of little interest to any one but her near neighbors on the east and west, and to her own people, who have plenty of patriotic pride and affection. But the fate which has overtaken her since the Peace Circular was issued affords a very striking object lesson. The facts are simple and can be easily stated. There are no complications with foreign powers, as is the case with China; nor is there the fear of internal disorder which, rightly or wrongly, has long been connected with the student class in Russia. It therefore affords a fair illustration of the methods of Russian government.

Finland became a province of Sweden in the fourteenth century. The two races intermarried to some extent, but the recognition of distinct nationality remained. Sweden had no more loyal subjects than the Finns in the wars which took place with Russia, although there were occasions when the Russians tried to arouse in the province a national sentiment, hoping thus to weaken their Swedish opponents and to create a barrier, or what is now called a "buffer state," between the two countries. They were unsuccessful; but early in this century, in 1808, Sweden was overpowered by her stronger neighbor and lost her control over her old province of Finland. The Czar of Russia at that time was Alexander I, a man of humane and noble character. He assembled the representatives of the Finnish people, recognized and promised to maintain the constitution under which they had long been governed, guaranteeing the rights and liberties hitherto enjoyed by the inhabitants of what now became known as the Grand Duchy of Finland. The same pledge was given by his successor Nicholas, while Alexander II, in 1869, and Alexander III, in 1886, granted additional powers of self-government. The present Czar, Nicholas II, when he came to the throne in 1894,

confirmed the Finnish constitution, swearing to uphold the fundamental laws and liberties of the country.

The form of home rule which Finland enjoys is simple. The Czar controls relations with foreign countries, commands the army, appoints the governor-general and the members of the Senate, an administrative council of twenty persons who must be Finns, and who are continuously in office during their term of three years. The Diet, or parliament, consists of four houses, or orders: the nobles, the clergy (Lutheran), the burgesses (representing the towns), and the peasantry. Each house votes separately, and all have equal authority. Their consent is necessary for the making and repealing of laws, the laying of taxes, and the levying of troops. Any action of the Diet must have the Czar's consent. It sits at Helsingfors, the capital of the country, and must be summoned at least once in five years.

Finland is prosperous and contented, and her people believe that her well-being is due to their constitutional government, which is suited to their national character and to which they are firmly attached. Russian government officials have looked with resentment on the comparative freedom of the Finns, their light taxation, and the small contribution they make to the military power of the empire. The Russian press has very little influence in comparison with that of countries in which education is more general and freer from government censorship; but such as it is it has agitated the Finnish question during the past ten or twelve years on religious as well as on political grounds; for the Russian state church has little toleration for those who profess a different form of religion. The Finns have not been seriously disturbed. Russian Czars had kept faith with them for ninety years, and they in their turn had been true to their obligations, and had confidence in their sovereign.

The Czar's Peace Circular proposing a diminution of standing armies was issued in August. In October the Czar laid before the Diet of Finland a Military Reform bill, which involved a change in one of the fundamental laws of the constitution. According to Finnish law, every man is liable to military service at twenty-one years of age. The standing army consists of 5,600 men, one-third of this number being annually drawn by ballot from a population of two and a half millions. They serve for three years, and are then placed in the reserve for two years. Those young men who are not drawn for the regular army are placed in the reserve at once, and receive thirty days' military training every year for three years. They are commanded by native officers, and are intended for the defense of their own country; only for special reasons may they be sent beyond the frontier. The new military bill provided that in addition to the army in Finland over 5,000 young men should be sent every year to serve in any part of Russia under Russian officers, instead of going into the reserve; and that the term of service spent with the colors, whether for home defense or for imperial service, should be raised to five years, with thirteen years in the reserve. This great increase in the military force would naturally involve a corresponding increase in taxation, and the country would also be deprived of the labor of almost all the young men of 21 to 26 years of age.

The Diet was not asked to give its consent to this bill, according to constitutional requirement; it was asked only to express an opinion on its provisions. The bill was then to be submitted to the state council at St. Petersburg, a body composed of Russians, and to become law after receiving the Czar's sanction. The people of Finland were roused by this infringement of their rights, and a respectful remonstrance was addressed to the Czar. His reply, received in February, was in the form of a manifesto, to the effect that the Diet had authority with regard to the local laws of Finland, but he claimed for himself the right to decide whether legislation did or did not affect the general interests of the empire. It is evident that laws of any kind may be treated as of imperial interest. Education, transport, customs, taxation, the coinage, the criminal code, and many other matters may, under this pretext, be taken from the control of the Diet, and placed in charge of the state council at St. Petersburg.

The people have appealed to their sovereign. Their highest officials made two unsuccessful attempts to see the Czar. A monster petition, signed by half a million persons, about half the adult population of the country, was sent to him by elected delegates. The Czar refused to accept it until the signers had received the approval of the (Russian) governors of the provinces of Finland. The lovers of liberty in Europe have attempted to aid the Finns in this strait. A deputation of distinguished men

representing eight different countries visited St. Petersburg, bearing petitions signed by nearly 1,000 names, including many that are eminent in the world of science and letters in Europe. As individuals these gentlemen were treated with courtesy and hospitality; but the Czar declined to receive the addresses pleading for justice and for a reconsideration of his decision. The Diet has acted in a manner worthy of the representatives of a free people. It has refused consent to the Military Bill, but proposed a counter measure which is to some extent a compromise. It affirms that the Czar's February manifesto has not the sanctity of law in Finland, and that laws relating to military service must conform to the decision of the Diet. Thus they make their last stand for the independence of their country, and in the face of almost hopeless odds resolve to die fighting, if die they must.

They believe that they have just one chance in the unequal conflict with their powerful opponent, and that depends on the character of the Czar himself. It is their conviction that he is in ignorance of the true state of the case, and unduly influenced by his ministers; were he unfettered they believe he would sustain the constitutional rights of the country.

Nicholas stands as the representative of his government. He appeals to Europe as the advocate of mercy and peace at the moment when a loyal people are being robbed of the ancient liberties he has sworn to protect. Is he the Autocrat of all the Russias? or is he only a tool in the hands of his ministers? and in which of these characters will he pledge his faith to Europe and to the world when he accepts the decisions of the Peace Conference now in session?

A HORSE-CHESTNUT.

George McC. Robson, M. A.

An Arithmetical Trick.

IT IS an indisputable fact that, of all members of the chestnut family, the horse-chestnut tree attains the greatest age, and its fruit acquires the most objectionable flavor. In making this statement, we have no desire to enter into controversy with the botanists, or to trespass on their territory. In order to avoid bloodshed and international complications of a grave character, we hasten to explain that the horse-chestnut to which we refer is not the buckeye, but a certain species of arithmetical trick. Occasionally, one of these tricks, of most venerable antiquity, arrays itself in a spring suit of bright-green leaves and tries to pass current as a novelty. Many people sympathize with the diner-out who said he liked mutton pretty well, but despised "mutton dressed lamb fashion"; in this spirit some of our readers may enjoy a simple old trick which makes no pretension of novelty. The trick consists in a peculiar method of performing multiplication in certain cases. It is easy to see that correct products are obtained by this peculiar method in the following examples.

The product of 84 and 67 is found in this way: $7 \times 4 = 28$, write down 28 as part of the product and carry 1 to the next figure of the multiplier; then $6 + 1 = 7$, and $8 \times 7 = 56$; write 56 to the left of 28, the part of the product previously found. The whole product is 5,628.

$$\begin{array}{r} 84 \\ 67 \\ \hline 5{,}628 \end{array}$$

As another example, we may find the product of 34 and 62. We have $4 \times 2 = 8 = 08$, which gives the first two figures of the required product. Carrying 1 to 6, we get 7 for the next multiplier, and $3 \times 7 = 21$, which must be placed to the left of 08, the part of the product already found. Thus, the product is 2,108.

$$\begin{array}{r} 34 \\ 62 \\ \hline 2{,}108 \end{array}$$

It is evident that this peculiar method of multiplication is not applicable in all cases. It is necessary, therefore, to have some way of determining when this method can be used. Any person possessing a knowledge of elementary algebra can easily devise a method of detecting the cases to which it applies. We shall not give a general rule for determining its applicability, but shall merely point out the following case in which this method effects a considerable saving of labor.

This method can be applied to find the

product of two numbers, when the part preceding the figure in the units' place is the same in both numbers, and the sum of the units' digits is ten. For example, this method gives the product of 197 and 193; $7 \times 3 = 21$; 1 carried to 19 makes 20, and $19 \times 20 = 380$. The product, therefore, is 38,021.

$$\begin{array}{r} 197 \\ 193 \\ \hline 38{,}021 \end{array}$$

There are two points to be noted particularly. *First*, the product of the figures in the units' place must be written with two figures, so as to fill both the units' and the tens' place; *second*, the amount to be carried is always unity. Thus, in multiplying 999 by 991, we have $9 \times 1 = 9 = 09$, which gives the first two figures of the product. Carrying 1, we have $99 + 1 = 100$, and $99 \times 100 = 9{,}900$. Thus, the product is 990,009.

$$\begin{array}{r} 999 \\ 991 \\ \hline 990{,}009 \end{array}$$

Endless variety can be given to this method by a little ingenuity. Thus 9,988 may be multiplied by 9,912 in the following manner: $88 \times 12 = 1{,}056$, which gives the first four figures of the product; 1 carried to 99 makes 100, and $99 \times 100 = 9{,}900$. Hence, the product of 9,988 and 9,912 is 99,001,056. Here we see that the part preceding the tens' digit is the same in both numbers, and the sum of the parts succeeding the hundreds' digit is one hundred; any two numbers possessing this relation can be multiplied in this way.

$$\begin{array}{r} 9{,}988 \\ 9{,}912 \\ \hline 99{,}001{,}056 \end{array}$$

ELECTRICITY FROM CARBON.

BEFORE the invention and introduction of the dynamo, primary batteries were the only available source of current when any considerable quantity of electricity was needed. By using large batteries, a considerable amount of energy could be developed; but the cost of the materials consumed was high, and consequently batteries of this kind were never able to compete with the steam engine in the production of power for industrial purposes. With the invention of the dynamo the cost was greatly reduced, electrical energy produced by the steam engine and dynamo costing only about one-seventeenth as much as energy produced by primary batteries. The modern dynamo is a very efficient machine, but when we come to look at the amount of power we are getting in the form of electricity, as compared with the actual energy produced by the heat of combustion of the coal under the boilers, we are brought face to face with the fact that we are only getting from 10 to 12 per cent. of the energy thus represented. This is due largely to the unavoidably low thermodynamic efficiency of the steam engine and to the numerous other heat wastes.

For the reasons mentioned above, it is little to be wondered at that so many attempts have been made to find some means of consuming carbon, with the production of electricity and without the intervention of either boiler, steam engine, or dynamo. Every now and then a cell is brought out which, it is claimed, consumes carbon, but none of these have so far been successful. Mr. Willard E. Case has recently brought out a cell in which carbon is oxidized by the oxygen of the air, at ordinary temperatures, with the production of electricity. The form of cell used by him consisted of a vessel containing a solution of ferric chloride. In this two electrodes were immersed, one consisting of carbon and the other of platinum. Air was then passed through the cell, and it was found that an electromotive force was set up between the electrodes. In this cell the ferric chloride is reduced to ferrous chloride by the action of the carbon, and oxygen is set free at the carbon. This oxygen combines with the carbon, and the energy represented by this combination reappears in the form of an electric current. The air acting on the ferrous solution changes it back to ferric, so that, theoretically, the action of the cell is continuous so long as any carbon is left. The ferric-chloride solution in this case acts as a carrier of oxygen from the air to the carbon; and, although the cell is yet in its experimental stage, the principle on which it works looks promising, and may lead to a cell of practical utility.

The problem of generating electricity by the direct oxidation of carbon is a difficult one, but its solution would mean such an immense saving that anything which may tend towards its accomplishment is worthy of consideration. On the other hand, it may be found that any such process may not be any more efficient than the ordinary process of converting the energy stored in coal into mechanical energy by means of the steam engine and boiler.

ANSWERS TO INQUIRIES

Note.—*Address all letters containing questions to be answered in this department to* The Mechanic Arts Magazine, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(190) Why does an ordinary suction pump take more air in with the water at night than during the day, thus causing more or less violent pounding in the water cylinders? The conditions in regard to the above are as follows: We have a 16″ × 22″ × 12″ × 12″ Snow pump, compound and center-packed. We are lifting water at present 22 feet, and the elevation to which it has to be raised is 300 feet. We get the water from a series of 44 driven wells (size, 2-inch points), and they are all connected on the surface into a 12-inch main suction pipe; the length of the suction pipe from the extreme end to the pump is about 1,400 feet, and the wells are spaced 30 feet apart. In the daytime we are running at about 38 revolutions per minute, but at night we cannot make more than 35 with smooth running, and the colder the night the worse the pump thumps. The pump is out of doors, with no shelter whatever. The suction line seems to be perfectly tight, and the vacuum gauge shows about the same day and night. We hope that you can throw some light upon this subject.

J. M. A., San Diego Co., Cal.

Ans.—We cannot think of any reason why the pump should take more air at night than during the day, and we are inclined to lay the trouble to some other cause. It is often very difficult to account for troubles of this kind, even when a careful personal examination of all the conditions can be made, and we can only offer some general hints that may put you on the right track and enable you to discover and correct the fault. Our attention was once called to a case in which a pump fitted with hard-rubber valves gave trouble through a failure to hold water in the suction pipe when stopped, thus necessitating priming before it could be made to take water when started again. A careful examination showed that the valves were slightly warped and did not seat properly. They were replaced by soft valves, and there was no further trouble. In your case, it may be that, if hard valves are used, the water is enough warmer during the day to soften them slightly and make them seat better. It is probable that an air chamber on the suction pipe—a *vacuum chamber*, as it is sometimes called—would improve the action of the pump, and make it possible to run at a considerably higher speed without water hammer. The capacity of the chamber may be twice the displacement of the pump plunger for a single stroke. It is possible that the difference in temperature between day and night affects the air supply in the air chamber on your discharge pipe to such an extent as to cause the trouble you describe. Cold water absorbs more air than warm; the air would therefore be more quickly exhausted from the chamber during the night; also, the colder air would contract considerably in volume, and so further reduce the efficiency of the air chamber. A gauge glass on the air chamber is very useful in enabling the engineer to watch the air supply.

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(191) What are the ingredients used in the manufacture of powdered, paper, and liquid bluing?

J. S. H., Boston, Mass.

Ans.—We do not understand the term "paper bluing." Powdered and liquid bluing are made from various colors, such as aniline blue, indigo sulphate, Prussian blue, Berlin blue, etc. A good recipe for a disinfecting laundry blue (solid) is here given: Mix together 16 parts of Prussian blue, 2 parts of carbolic acid, 1 part of borax, and 1 part of gum arabic into a stiff dough. Roll it into small balls and coat them with gelatine or gum to prevent the carbolic acid from escaping. For a liquid blue the following is recommended: Dissolve in 15 parts of water 1½ parts of indigo-carmine; add ¾ part of gum arabic. In the manufacture of blue paper ultramarine blue is generally used.

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(192) (*a*) I wish to know how to find the size of wire and the number of turns in the primary and the secondary coils of a transformer for a given number of lights. (*b*) Suppose the primary coil of a transformer had 1,000 turns of No. 16 magnet wire, and I had taken off 100 turns, how could I find the number of turns of a larger or smaller wire than No. 16 to replace the 100 turns I had taken off, the transformer to act the same, that is, the voltage of the secondary and the capacity in amperes to remain as it was with the 1,000 turns of No. 16 wire? (*c*) How can I find the total voltage drop due to copper, leakage, hysteresis, and eddy currents?

G. V., New York.

Ans.—(*a*) The formula determining the number of primary turns is as follows:

$$T_p = \frac{E_p \times 10^8}{4.44 \times N \times 60},$$

where T_p = primary turns;
E_p = line voltage;
N = maximum magnetic flux through core.

The number of turns in the secondary will bear the same ratio to the number of primary turns as the secondary voltage does to the primary voltage. (*b*) You cannot change the number of primary turns without changing the number of secondary turns in the same proportion, and still keep the same ratio of transformation. (*c*) You can determine the copper losses by measuring the resistances of the primary and the secondary, and multiplying these values by the respective current squared. That is, the primary copper loss is

$$C_p^2 \times R_p,$$

where C_p = primary full-load current;
R_p = primary resistance (hot).

The hysteresis loss varies with the frequency of the current and the density of magnetic flux. The loss due to eddy currents being small, it is generally assumed to be included in hysteresis loss. The drop at full load, due to leakage, can be determined by

subtracting the drop due to all other losses from the total drop. An article will be published shortly in THE STEAM-ELECTRIC MAGAZINE on the subject of transformer testing, which will give you the requisite information for carrying on such tests as you desire.

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(193) With 3 pounds of No. 36 single cotton-covered magnet wire used as a secondary of an induction coil, (a) what size and how much should be used for primary? (b) how large a condenser will be needed? (c) By doubling each of the above specifications, should the spark be twice as long?

R. F. P., Somerville, Mass.

ANS.—(a) The primary should be made of two layers of No. 14 B. & S. gauge copper wire. Its length will depend on the arrangement of the secondary, but the number of primary turns should not be less than 200. (b) The inductance of the primary will depend on the rate at which the vibrator works, and on the current strength in the primary. Consequently, you will have to make several tests in order to determine what size of condenser is required. We would recommend you to try one with tin-foil sheets about 4 in. $\times$ 3 in. in size. Use 100 sheets. By using an interrupter, such as described in THE STEAM-ELECTRIC MAGAZINE, May, 1899, article entitled "A New Current Interrupter," no condenser will be required. (c) To double the length of the spark would not necessarily require doubling all of your specifications. It would still be necessary to determine the flux density in the core, and then decide whether this could be increased without suffering too much loss from hysteresis. You can double the capacity of your coil by employing the apparatus described in the article referred to above. In case you use the interrupter referred to, make the primary of four layers of No. 16 B. & S. wire, or, if you have room, wind six layers. The increased self-induction due to the greater number of turns on the primary coil will aid the operation of the interrupter.

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(194) What is a choke coil, and for what purpose is it used? Where can I purchase one?

J. F. G., Navarre, Ohio.

ANS.—A choke coil is a coil having a large amount of self-induction, and is used, in general, in alternating-current work, to cut down the current flowing in the circuit, by causing the electromotive force due to self-induction to oppose the electromotive force which is tending to drive current through the circuit. Such coils are usually constructed by winding a considerable number of turns of insulated copper wire upon an iron core. The core is frequently made in the form of a complete ring, so that the magnetic lines of force are given a complete circuit through the iron. You could probably obtain a coil adapted for any particular purpose from the Western Electric Co., of Chicago.

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(195) Given, standing vertical in a pond of water, a pole 100 feet high from the surface of the water to the top, circular in section, 6 inches in diameter at the top, tapered straight to 24 inches in diameter at the surface of the water. A rope 1 inch in diameter is attached to the top and wound close and tight from top to bottom; at the bottom it is tied to a duck's leg; the duck swims away, keeping the rope taut until it is all unwound. (a) When all the rope is unwound, how far is the duck from the bottom of the pole? (b) How far does the duck travel?

H. K., Evansville, Ind.

ANS.—(a) The central line of the rope will lie on the surface of a right circular cone. Let $2\,a$ denote the vertical angle of this cone; h, its altitude measured from the vertex to the surface of the water; p, the thickness of the rope; x, the vertical distance from the vertex of the cone to the point where the rope at any instant leaves the cone; and l, the length of the rope that has been unwound at this instant. Then l is given by the formula:

$$l = \frac{p}{2\pi \sin a}\left[\frac{\pi h \tan a}{p}\sqrt{1 + \frac{4\pi^2 h^2 \tan^2 a}{p^2}} + \tfrac{1}{2}\log_e\left\{\frac{2\pi h \tan a}{p} + \sqrt{1 + \frac{4\pi^2 h^2 \tan^2 a}{p^2}}\right\}\right]$$
$$- \frac{p}{2\pi \sin a}\left[\frac{\pi x \tan a}{p}\sqrt{1 + \frac{4\pi^2 x^2 \tan^2 a}{p^2}} + \tfrac{1}{2}\log_e\left\{\frac{2\pi x \tan a}{p} + \sqrt{1 + \frac{4\pi^2 x^2 \tan^2 a}{p^2}}\right\}\right]$$

(b) The formula for the distance traveled by the duck would necessarily be a great deal more complicated than that given above for the length of rope unwound, and could not possibly be of any use to you if we took the trouble to derive it.

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(196) How should I go about it to make a layout for a galvanized-iron conveyer, 6 inches outside diameter, 2 inches pitch, to be soldered upon a ½-inch pipe of same material? W. C. W., Redlands, Cal.

ANS.—See HOME STUDY MAGAZINE, January, 1899, Answers to Inquiries, No. 542.

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(197) (a) Give the elementary principles of trigonometry. (b) Give details of the working parts of the block-signal system in use on railroads. (c) Give the method of laying out a tappet cam, such as used in quartz mills. C. B. R., Angel's Camp.

ANS.—(a and b) These two questions are too general for us to answer in these columns. (c) The cams are laid out as the involute of a circle whose radius is the distance from the center of the cam-shaft to the center of the stamp stem. To lay off this curve, a circular disk of the proper diameter is cut; a string is then fastened by one end at any point of the circumference and the other end is carried around to a point diametrically opposite, the string being drawn tight along the edge of the disk. Then place the disk on the paper or board to be marked, and unwind the string, keeping it always taut. A pencil at the free end of the string will trace the curve, which is the curve of the cam-face. In practice, this curve is flattened slightly at the extreme end.

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(198) I wish to make a spark coil that will produce a spark just large enough to ignite gasoline vapor. I want to know what kind and size of cell to use, the size of core for the coil, and the size and amount of wire for both primary and secondary. I want to use the circuit-breaker in the primary.

S. G. M., Denver, Col.

ANS.—Construct a core of a bundle of iron wires, making it 5 inches long and ½ inch in diameter. Insulate it with two or three layers of vulcanized paper. The primary should consist of two layers of No. 14 B. & S. wire; it should have an inside diameter sufficiently large to slip on the insulated core, and should cover the entire length of the core. Before placing it on the core, it should be dipped in melted paraffin, and the latter allowed to harden. The secondary should be wound in two sections of the same length, but the inside diameter of one of these sections should be ½ inch larger than that of the other. The two should superpose each other, and should be placed centrally on the core. The annular space between them should be filled with melted paraffin. The secondary, like the primary, is to be immersed in melted paraffin before placing it in position on the core. Four ounces of No. 36

B. & S. wire should be used for each section of the secondary. The two sections should be connected in series, care being taken to connect the proper ends together, otherwise the induced currents in the two sections will oppose each other. Use a Wehnelt interrupter in the primary circuit. The spark gap between the secondary terminals should be ½ inch. For the construction and proper operation of the Wehnelt interrupter, see THE STEAM-ELECTRIC MAGAZINE, May, 1899, article entitled, "A New Current Interrupter."

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(199) Give the name and price of a good book on civil engineering—one treating water works, drainage, sewerage, the construction of reservoirs, dams and foundations, etc. X.

ANS.—The latest and most complete book on civil engineering is Patton's "Treatise on Civil Engineering" ($7.50). Rankine's "Civil Engineering" is a good book, but in many respects behind the times. Much useful information is found in Trautwine's "Civil Engineer's Pocket-Book" ($5.00). Any of these books can be obtained through The Technical Supply Co., Scranton, Pa.

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(200) (a) Can you tell me how to become a member of the National Master Plumbers' Association, its dues, requirements, who is eligible, and the advantages of being a member? (b) Where can I get a small working model, in wood, of an eccentric and slide valve for a steam engine?
H. E. M., Pasadena, Cal.

ANS.—(a) Write to Mr. Andrew H. Brown, Secretary, 627 Columbus Avenue, New York City, N. Y.; or to Mr. John L. E. Firmin, 1244 Valencia Street, San Francisco, Cal., who is one of the executive committee. Either of these gentlemen will give you all necessary particulars. (b) We do not know of any one that makes a specialty of working models in wood. Our advice is that you order what you want from a model or pattern maker.

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(201) Kindly give formula for oxidizing brass plates either brown or black.
G. H. R., Brooklyn, N. Y.

ANS.—The dead black on optical instruments is produced by dipping the brass parts into a solution of platinum chloride. A lustrous black is obtained in the following way: Mix equal parts of copper-sulphate and sodium-carbonate solutions hot. Filter and wash the precipitate on the filter. Transfer the precipitate to a glass beaker and dissolve in ammonia. Dilute the solution with water and add a little plumbago; then heat to 100° F. The brass article must be thoroughly cleaned and left in this bath until black; wash the article in water and dry in sawdust. Prepare only as much solution at a time as you expect to use.

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(202) Can you give me a recipe for a good soap that will float in water, and be in every way suitable for toilet purposes? A. D. S., Flint, Mich.

ANS.—We submit the two following recipes from a reliable source: (1) Good oil soap, 14 pounds; water, 3 pints. Melt together by the aid of steam or water bath, and heat the mixture thoroughly together until it is at least twice its initial volume. For 14 pounds of soap a pan of 18 gallons capacity should be used. Frame and cool it. Do not dry it in a warm room or a drying oven, or it will shrink considerably and become fissured. Have a thickness of from 6 to 7 inches in the frames. Perfume and color as desired; from ½ to 1 dram of vermilion per pound of soap will do. This will be ready for cutting up in a week. (2) Olive oil or almond oil soap, 5 pounds; soft water, 1½ pints. Expose the ingredients in a bright copper pan to a steam or water heat, and thoroughly heat and agitate until it has doubled its volume. Then pour into frames, cool quickly, and cut up when hard. Color and perfume it as desired. This soap will float on water and will also lather freely, but will not stand much soaking, as it quickly softens.

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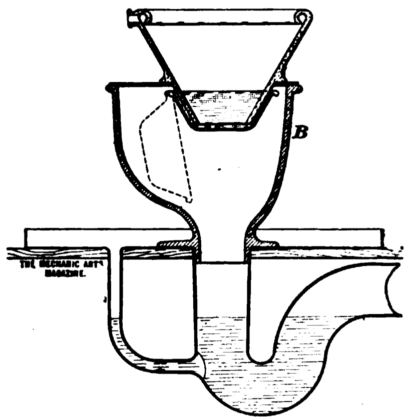
(203) What is a fouling chamber? This question was asked an applicant for a Master Plumber's License, by the Board of Examiners.
F. E. R., Jamestown, N. Y.

ANS.—A fouling chamber, as understood by plumbers, is simply a chamber which becomes foul. For example, in the pan closet illustrated here, the chamber *B*, or *trunk* as it is called in the trade, is a



fouling chamber of the worst kind. In any plumbing job, a fouling chamber is any chamber that gets foul because it cannot be cleaned.

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(204) (a) What is a horsepower? (b) In steam engines, about how much coal is consumed per horsepower per hour? (c) How can I figure the horsepower of a leather belt that drives a machine by means of a pulley? (d) Do you know of a book on mill superintending and where I can get it?
J. W. G., Philadelphia, Pa.

ANS.—(a) A horsepower is a unit by which the *rate* of doing work is measured. It is equivalent to the lifting of a 1-pound weight to a height of 33,000 feet in 1 minute, or a 33,000-pound weight 1 foot high in 1 minute. (b) The amount of coal consumed per horsepower per hour by a steam engine depends (1) on the quality of the coal; (2) on the economy with which the coal is burned and how the heat which it develops is utilized by the boiler; (3) on the size and type of the engine. Some of the best compound and triple-expansion condensing engines, with the best of boilers and good coal, have developed a horsepower per hour with 1½ pounds of coal. Few engines, however, use less than 3 pounds of coal per horsepower per hour, and many use much more. (c) A safe rule for finding the horsepower that may be transmitted by a single-leather belt is the following: Multiply the width of the belt in inches by its speed in feet per minute, and divide the product by 800; the result will be the horsepower that the belt will safely transmit. For a double-leather belt, multiply the result given by the rule by 1½. (d) Without knowing the particular kind of mill in which you are interested, it is difficult to recommend a book for your purpose. Some of the best collections of data, rules, and tables pertaining to the general principles of engineering and mechanics for the use

of millmen of all kinds are the following: "The Mechanical Engineer's Pocket-Book," by William Kent, price, $5.00; "A Manual of Rules, Tables, and Data for Mechanical Engineers," by D. K. Clark, price $5.00. These books may be obtained from The Technical Supply Co., Scranton, Pa.

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(205) We have a groaning engine. The groan comes as the piston nears the head-end, just as the dashpot at the crank-end drops. The engine is running ahead; oil does no good; keeping steam well down, or so as to just keep the engine at speed, stops the groan. The cylinder is in good condition; engine has been running for about 2½ years; has always groaned, but has been worse during the last few months; the cylinder is 18 in. × 48 in. What, in your opinion, is the cause of the groan? Can you suggest a remedy? A. J. M., Selma, Ala.

ANS.—The location of knocks, creaks, and groans in an engine is often one of the most exasperatingly difficult features of an engineer's work. The groan of which you speak may be located in almost any joint in the engine. We can only suggest that you carefully examine every joint, beginning at the one nearest to the apparent source of the noise, and see that all the working surfaces are smooth and well oiled and that all parts are so fitted and adjusted as to work freely and smoothly.

***

(206) Explain why high-tension electric current transformed down to 110 volts is more economical than direct current at the same voltage.
W. E., Wilmington, Del.

ANS.—The greater economy attending the use of alternating currents lies in their transmission at high voltages, thereby lessening the strength of current required to transmit a given amount of power. For a constant amount of power the loss varies inversely as the square of the voltage employed, neglecting losses due to leakage.

***

(207) (*a*) I would like to know how to construct a dry battery that can be charged in series with a 16-candlepower 110-volt lamp. (*b*) I have a U. S., 6-light, series, arc dynamo, giving a constant current of 6.8 amperes, and having a voltage of 300 across the brushes. Can it be run as an incandescent machine? If so, how? J. B. S., Chester, Pa.

ANS.—(*a*) The only satisfactory form of cell for recharging is the storage cell. These are not constructed in a dry form. (*b*) Connect the field in shunt with the armature through an adjustable resistance capable of carrying 6.8 amperes. Allow a current of this strength to flow. Rotate the armature at one-third the speed it ran as an arc generator.

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(208) How can I make an electrical soldering iron, and what length and size of resistance wire will be required to heat the iron on a 52-volt and a 110-volt circuit? H. W., Haverhill, Mass.

ANS.—Procure a copper tube, and, having insulated it with asbestos, wind 80 feet of No. 24 German silver wire on it. Insulate each layer of wire with a layer of asbestos. Wind the wire tightly, and in doing so keep adjacent convolutions separated. Do not let the winding approach closer than 1 inch to one end, and after having wound the coil slip over it a cast-copper "iron." The copper tube can be threaded into the nose of the "iron." The handle end of the iron can be closed by means of a copper washer threaded on the tube. The terminals can be brought out through the tube and wooden handle. This will make a soldering iron of approximately the same shape and size as one of ordinary construction. The mechanical proportions and design we will leave to your ingenuity. For a 52-volt circuit, use one-half the quantity of wire. If used on an alternating-current circuit, the coil should be wound non-inductively.

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(209) I have a series magneto-generator whose bell coils are 250 ohms each. I wish to work it on a series circuit with five 80-ohm magnetos, but its resistance is so great as to interfere with the working of the system; what is the best way to remedy the trouble? J. H. E., Portsmouth, Va.

ANS.—Connect the two bell coils in parallel, taking care that they are properly connected, i. e., so that the currents in the two circulate around the core in opposite directions. If this change does not produce the required result, rewind the bell coils with wire of the same size as is on the other magnets, so that each shall have a resistance of 40 ohms. If the system still fails to work, it will indicate that the generator supplying the current to the system is not sufficiently powerful for the new condition, and a more powerful generator will have to be substituted.

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(210) (*a*) Show how to cut a keyway in a cast-iron pulley, the bore of which is 1 inch in diameter and 3 inches through; it must be done by hand. (*b*) Publish table of standard square threads per inch from ¼ inch to 4 inches in diameter. (*c*) Where can I get a complete set of castings with working drawings for a 1- or 2-horsepower steam or gasoline engine? A. W., Austin, Texas.

ANS.—(*a*) We would not do it by hand—not if there was a slotter convenient. It is an easy matter to put these keyways in the male piece (first-year apprentice's work), but the female piece, however short, is always slotted. However, to do the present job by hand, use a crosscut chisel, as ordinarily, and cut through half way from each end. The length being so great compared with the bore, you will have to grind your chisel rather differently—more like a side chisel; it depends on the width of chisel, 1½ inches from the end. You will find it necessary to finish off with a square file—something you would not think of doing in a male piece, assuming you could handle your chisel well. You have more command over your chisel in latter case; can get down to your work better. In marking off the hole, if you have not a box square small enough, mark the width of keyway off on the two faces of hub, and join up inside with a small straightedge—your 4-inch rule will do. If you have many of these keyways to cut, it will pay you to put the job out, if you have not a slotter of your own. (*b*) There are no fixed standards for square threads as for the V thread, because square threads are mostly used for screws for transmission of motion and power, and their proportions depend on a multitude of considerations. Usually, however, the pitch of square threads is taken as being double that of the standard V thread. (*c*) Write to Palmer Bros., Box H, Mianus, Conn.

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(211) I want to make a 10-inch, 4-bladed screw propeller. Kindly tell me what pitch to make the blades at the outside and also what shape to make them so as to get the most power. Give the name of any good book that will give me up-to-date ideas about screw propellers. A. J. H., Peterboro, Pa.

ANS.—The pitch depending on the speed of the vessel, the slip of the propeller, and the number of revolutions per minute, we cannot tell you what pitch to use, as you omitted the data necessary for its calculation. If you wish to study the propulsion and powering of vessels, with special reference to screw propulsion, we can recommend "The Resistance and Propulsion of Ships," by William F. Durand; price $5.00. This book may be obtained from The Technical Supply Co., Scranton, Pa.

(212) (*a*) We have a double 18″ × 24″ geared hoisting engine which hoists 5 cars a trip out of an 18° slope, 1,200 feet long, in 1 minute 50 seconds. Each car weighs 1,500 pounds, and holds 3 tons. We use a wire rope 1¼ inches in diameter. The driving gear on the engine has 132 teeth; diameter of drum is 9′ 4″; steam pressure, 90 pounds gauge. We desire to increase the number of cars from 5 to 7 per trip; but the above engine will not haul them with 90 pounds of steam. Kindly say what size cylinders will be necessary to do the work; also, show how the resistance of the 7 cars on the 18° slope is figured, giving car friction and engine friction you allow. (*b*) Give rule for figuring frictional loss in a water column. N. H., Frontier, Wyoming.

ANS.—(*a*)

$$\begin{aligned} \text{Weight of rope} &= 2.5 \times 1{,}200 = 3{,}000 \text{ lb.} \\ \text{Weight of cars} &= 7 \times 1{,}500 = 10{,}500 \text{ lb.} \\ \text{Weight of coal} &= 7 \times 3 \times 2{,}000 = 42{,}000 \text{ lb.} \\ \text{Total load} &= 55{,}500 \text{ lb.} \end{aligned}$$

Tension in rope $= 55{,}500 \sin 18° + \dfrac{55{,}500 \cos 18°}{40}$ $= 18{,}470.2$ lb. ($\frac{1}{40}$ being the coefficient of friction).

Assuming a single track in slope, the power required to hoist entire load $= \dfrac{18{,}470.2}{1\frac{5}{6} \times 33{,}000} = 366.35$ horsepower.

Number of revolutions of drum per minute is

$$\frac{1{,}200}{9\frac{1}{3} \times 1\frac{5}{6} \times 3.1416}.$$

Not having number of teeth on the gear-wheel on the drum shaft, assume ratio of reduction to be 4:1. Therefore, number of strokes of engine is

$$\frac{2 \times 4 \times 1{,}200}{9\frac{1}{3} \times 1\frac{5}{6} \times 3.1416} = \frac{2 \times 4 \times 1{,}200 \times 3 \times 6}{28 \times 11 \times 3.1416}.$$

Allowing a loss of 10 per cent. in the engine, and 6 per cent. in the gears, the mean effective pressure, which should be determined from an indicator card, is $\frac{2}{3} \times 90 = 60$ lb.

$$366.35 = \frac{.90 \times .94 \times 60 \times 24 \times 3.1416 \times R^2 \times 1{,}200 \times 3 \times 6 \times 2 \times 4 \times 2}{12 \times 33{,}000 \times 28 \times 3.1416 \times 11} = \frac{2{,}923.77\, R^2}{847}$$

in which R = radius of cylinder in inches.

$$R = \sqrt{\frac{366.35 \times 847}{2{,}923.77}} = 10.3.$$

Therefore, diameter of cylinder is

$$10.3 \times 2 = 20.6, \text{ or, say, 21 inches.}$$

(*b*)
$$H = \frac{Q^2 L}{1{,}000\, D^5},$$

in which H = total pressure head in feet required to overcome the frictional resistance to flow of water through a cast-iron pipe;
L = length of pipe in feet;
D = diameter of pipe in feet;
Q = discharge per second in cubic feet.

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(213) (*a*) How much electric power is required to decompose 1 cubic foot of water? (*b*) Give the name and price of a good book treating of the electro-decomposition of water. W. R. K., Bliss, Idaho.

ANS.—(*a*) 354 kilowatt-hours. (*b*) "Electrodeposition of Metals," by Langbein, can be purchased from The Technical Supply Co., Scranton, Pa.; price, $4.00.

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(214) (*a*) Does water begin to drop scale as soon as it enters a boiler? (*b*) How would you go about it to line up an engine in a side-wheel boat; also, in a stern-wheel boat? C. H. G., Morgan City, Fla.

ANS.—(*a*) The carbonate of lime becomes insoluble as soon as the water is heated to 212°, while the sulphate of lime becomes insoluble at 240°. When these substances have become insoluble, they precipitate. (*b*) A complete answer to this inquiry would take more space than can be spared here. We would recommend you to get a copy of HOME STUDY MAGAZINE, February, 1897. This publication is now THE MECHANIC ARTS MAGAZINE. In it you will find an article entitled "Lining an Engine." While the illustrations show a stationary engine, you will find the principles involved in the lining up of *any* engine to be so fully explained that you will be able to reason out for yourself how to go to work to line up an engine of any type or make.

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(215) (*a*) I have a corner of tract of land and plat of same, dated January 1st, 1860, all other line marks being destroyed; the reading on plat is N-46°E. What will compass read on this line on July 7th, 1899? (*b*) What is the simplest formula to get the declination of the needle? J. T. B., Camden, S. C.

ANS.—(*a*) The best thing to do is to obtain, if possible, from old records, the *observed* declination of the needle either at Camden or at some other place near by, at the time the survey was made. The difference between that declination and the present declination will give the difference between the old and the present magnetic bearing. If this is not possible, get the recorded observed declination in two different years, say 1890 and 1895; divide the difference between the years by the difference between the declinations, and multiply the result by the number of years elapsed since the survey was made. The product will give the correction to be applied to the old bearing in order to obtain the present one. Thus, the declinations at Knott Island (which is only a few miles east of Camden) in 1887 and 1890 were 3.55° and 3.70°, respectively, both west. The needle was therefore moving westward at the rate of $\frac{.15}{3} = .05° = 3'$ per year. Assuming the same rate between the years 1860 and 1899, the needle, in the latter year, will point 1° 57′ towards the west of its position in the former year. The bearing of your line will, therefore, be N (46° + 1° 57′) E = N 47° 57′ E, or, say, N 48° E. This is only a roughly approximate way of determining the present bearing. It is, however, of great value as a guide in retracing the line, as it tells the surveyor about where to look for old corners. (*b*) There is no simple formula for magnetic declination. Some complicated formulas have been published by Mr. C. A. Schott in the Report of the U. S. Coast and Geodetic Survey for 1888. Both in this report and in the one for 1889, he gives much valuable data. The declination of the needle and the probable law of its variation are given for several localities of each state.

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(216) (*a*) Please give full directions how to prepare one pint of nickelplating solution, and also explain how to connect the wires. (*b*) Explain how I can make a small galvanometer. E. I., Georgeville, Stearns Co., Minn.

ANS.—(*a*) Dissolve 1¼ ounces of the double sulphate of nickel and ammonia, commonly known as "nickel salts," in 1 pint of hot water. Strain when cool. The positive pole of the source of current supply should be connected to a plate of pure nickel suspended in the solution, known technically as the *anode*. The object to be plated is to be connected to the negative pole, and is known as the *cathode*. In series with the circuit a resistance box should be connected, that the current strength, and, therefore, the rate of deposition, may be governed. (*b*) A simple instrument for measuring the strength of a current may be made of an ordinary pocket compass and a piece of copper wire. Any bar magnet may be used if suspended similarly to a compass needle. Wind two or three turns of wire around the compass, in a plane perpendicular to the plane of suspension of the needle; that is, wind the coil over the top of and

underneath the compass. Place the instrument in such a position that the coil will lie in the magnetic meridian, that is, so that it lies in line with the needle when pointing north and south. A current passing through the coil will deflect the needle from its original position, and the amount of deflection is a measure of the current strength. Calibrate it, and construct a scale by comparing it with a standard milliammeter. A greater number of turns of wire increases the deflection for a given current. A good galvanometer can be purchased for a moderate price from The Technical Supply Co., Scranton, Pa.

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(217) I notice that Professor Dewar, who has liquefied hydrogen, says that absolute zero is $-494°$ F. This does not agree with the temperature, $-461°$ F., given as the absolute zero in the June number of THE MECHANIC ARTS MAGAZINE. Which of these is correct, and how is it determined?

W. H. G., Gaffney, S. C.

ANS.—The apparent large discrepancy is due to the fact that Professor Dewar estimates the absolute zero at 494° below freezing (that is, below 32° F.), while the 461° is taken below 0° F. Subtracting 32, Professor Dewar's value is 462° below 0° F., which differs from the other value by only 1°. The values given by different authorities vary from $-459°$ to $-462°$. The absolute temperature is determined from the coefficient of expansion of gases. A given volume of air at the freezing temperature of water is found to contract about $\frac{1}{493}$ of its volume when cooled 1° F.; hence, we reason that if we cool it 493° F. below freezing, the gas will contract until its volume is *nil*; that is, according to the kinetic theory of gases, the molecules of the gas will at this temperature cease to have motion. This point is called the absolute zero of temperature. Since it is 493° below 32° F., it is 461° below 0° F.

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(218) (*a*) How is the Thalen magnetometer used for detecting iron ores? What is meant by the sine-and-tangent method in using it? (*b*) Did not Edison make an instrument for a similar purpose? Where could I obtain particulars of his machine?

H. G., New Zealand.

ANS.—(*a*) The question is too comprehensive for these columns. A description of the instrument and the manner of using it is given in "Mines and Minerals," November, 1898. You can procure a copy of the magazine by addressing "Mines and Minerals," Scranton, Pa. (*b*) We are inclined to think that Edison did make such an instrument, but we know of no published description of it. You might obtain information by addressing T. A. Edison, E. Orange, N. J.

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(219) Of what commercial use is barytes (barium sulphate) except as a paint and as a glazing for paper? Is it much used in the above ways?

X. Y. Z.

ANS.—Barium sulphate is used for the above-named purposes only, so far as we know. No statistics exist to show the extent to which it is used.

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(220) (*a*) I have a 1-man-power electric motor. Can I utilize it for incandescent lighting? Is it possible, running this machine during the day, to store up the electricity in a storage battery for use at night? (*b*) If so, how many candlepower can I get out of it? (*c*) What is the best storage battery for the purpose, and where can I get it?

H. M. B., El Rio, Cal.

ANS.—(*a*) You probably mean a dynamo. We see no reason why you should not be able to use the dynamo for incandescent lighting or for charging a storage battery, provided it is properly constructed for such work. (*b*) You probably wish to know for how long a time a certain number of lamps can be lighted from such a circuit. According to Weisbach, 1 man-power is equal to about $\frac{1}{3}$ horsepower. Supposing your dynamo is a 110-volt machine. Its amperage will then be $\frac{746}{3} \div 110$, or 2.26 amperes. Connecting directly to the dynamo, you could light four 110-volt incandescent lamps. If the ampere-hour efficiency of the storage battery is assumed to be 80 per cent., it would have a capacity of $.80 \times 2.26 \times 10 = 18$ ampere hours. The storage battery would therefore light 36 lamps for 1 hour, 18 lamps for 2 hours, or 9 lamps for 4 hours. (*c*) There are several good storage batteries in the market. For more particular information on storage batteries you might inquire of The Electric Storage Battery Co., Philadelphia, Pa., The American Battery Co., Chicago, Ill., or The Storage Battery Supply Co., New York City.

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(221) Is there a formula that gives the standard diameters of steam-pipe screw-thread taps? Where is the diameter measured—at the small end, large end, or middle? Give table of the standard diameters for from 1-inch to 12-inch pipes.

W. H., Cincinnati, Ohio.

ANS.—The diameter is measured at the small end, and may be calculated from the formulas:

$$d_b = D - \left(.05D + 1.9 \times \frac{1}{n}\right);$$

$$d_t = 1.6\frac{1}{n} + d_b,$$

in which d_b = diameter of bottom of thread;
d_t = diameter of top of thread;
D = actual outside diameter of pipe;
n = number of threads per inch.

The following are the values obtained by the above formulas for pipes from 1 inch to 12 inches nominal diameter:

	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$
d_b . .	1.144	1.488	1.727	2.200	2.62	3.241	3.738	4.235	4.732
d_t . .	1.283	1.627	1.866	2.339	2.82	3.441	3.938	4.435	4.932

	5	6	7	8	9	10	11	12
d_b . .	5.291	6.346	7.34	8.334	8.39	10.445	11.687	12.612
d_t . .	5.491	6.546	7.54	8.534	9.59	10.645	11.887	12.812

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(222) Explain, with the help of illustrations, the proper method of laying in the ends of strands in splicing steel-wire cables.

READER, Mexico.

ANS.—To lay in the ends of strands in splicing a wire cable, clamp the cable in a vise to the left of the ends of the strands, and fasten a clamp to the right of the ends of the strands. Turn the clamp in the opposite direction to that in which the cable is twisted, until the cable is untwisted enough to allow the hemp core to be pulled out with a pair of nippers. Cut out about a foot of the core, 6 inches on each side of the intersection of the strands whose ends are to be laid in, and push the ends of the strands in its place. Then allow the cable to twist up to its natural position, and remove the vise and clamp. The strands tucked in generally bulge out. This bulging can be reduced by lightly tapping the bulged part of the strands with a wooden mallet.

(223) (*a*) What is the advantage of placing the draft pipe in combustion chamber to furnish hot air below the grate? (*b*) Can you explain why in the Holley pumping engine the valves in the water end in the delivery chamber that are next to the fly-wheel—that is, on the inside—wear out two or three to one as compared with the outer valves? The engine is a No. 6, Pattern A, small valve.

J. G. S., Seattle, Wash.

ANS.—(*a*) The advantages claimed for the placing of draft pipes in the combustion chamber of a boiler furnace are that the air in its passage through the pipe becomes heated, and thus makes the fire hotter and increases the economy with which the fuel is burned. Such an arrangement is also supposed to reduce the production of black smoke by making the combustion of the fuel more complete. It is very doubtful whether the real gain from any device of this kind is sufficient to pay for its cost. (*b*) We are unable to explain the difference in wear of the valves of which you complain.

***

(224) Kindly publish the Greek alphabet, giving the correct pronunciation of each letter.

D. C. W., Johnstown, Pa.

ANS.—We give the English pronunciation of the letters:

Α	α	(*al'pha*)	Ν	ν	(*nu*)
Β	β	(*be'ta*)	Ξ	ξ	(*zi*)
Γ	γ	(*gam'ma*)	Ο	ο	(*o mik'ron*)
Δ	δ	(*del'ta*)	Π	π	(*pi*)
Ε	ε	(*ep si'lon*)	Ρ	ρ	(*ro*)
Ζ	ζ	(*ze'ta*)	Σ	σ ς	(*sig'ma*)
Η	η	(*e'ta*)	Τ	τ	(*tow*, like *ow* in *cow*)
Θ	θ	(*the'ta*)	Υ	υ	(*yoop si'lon*)
Ι	ι	(*i o'ta*)	Φ	φ	(*phi*)
Κ	κ	(*kap'pa*)	Χ	χ	(*ki*)
Λ	λ	(*lamb'da*)	Ψ	ψ	(*psi*)
Μ	μ	(*mu*)	Ω	ω	(*o'meg a*)

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(225) (*a*) Give list of the leading manufacturers of chinaware. (*b*) Give the names of those firms who make a specialty of jugs and pitchers. (*c*) Of what wood are parallel rulers and set squares made, and how are they prevented from warping?

V. D. T., Ontario, Canada.

ANS.—(*a* and *b*) A list of the leading manufacturers of chinaware would be too extensive to insert in this department. Consult the advertising pages of some magazine devoted to the decorative arts. (*c*) Set squares and triangles are usually made of pearwood, cherry, or mahogany, selected from well-seasoned stock that is not likely to shrink or warp after it is worked to the required form.

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(226) (*a*) What are *anchor guys?* (*b*) What are *guy stubs?* (*c*) What are *anchor logs?* The above expressions are used in treatises on electric-pole line-construction. C. M. M., Reisterstown, Md.

ANS.—(*a*) *Anchor guys* are stays, suitably secured to a post or anchor, for the purpose of steadying an overhead wire system. (*b*) *Guy stubs* are stubs or anchors to which the guys are secured. (*c*) *Anchor logs* are logs partly buried in the ground and serving as anchors for telegraph poles.

***

(227) (*a*) Kindly tell me how to make the black oxide of copper used in the Edison-Lalande battery for igniting the charge of gasoline in engine. (*b*) What is the meaning of the term "roasting" when used in connection with the oxidizing of metals? J. W. S., Galena, Ill.

ANS.—(*a*) The cathode of the Edison-Lalande battery consists of molten plates of cupric oxide and magnesic chloride held in copper frames. Both cupric oxide and magnesic chloride can be procured at little cost from any dealer in chemicals. We do not know the proportion in which these two compounds are mixed, nor the exact manufacturing process of the plates. (*b*) The term "roasting" is not employed directly in connection with oxidizing metals, but is used in connection with "ores"; it then simply means the burning off of some undesirable constituent of the ore, as, for instance, lead ore is roasted to get rid of the sulphur present in the ore, whereby the oxygen takes the former's place.

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(228) (*a*) Is it a fact that cast iron containing one-tenth of one per cent. of aluminum will not shrink while solidifying, and will be free from blowholes? (*b*) Is the presence of aluminum in cast iron any advantage in ordinary machine castings?

A. A. W., Sandwich, Ill.

ANS.—(*a*) It is claimed that the shrinkage of iron is diminished by the addition of aluminum. It is also claimed that it prevents the presence of blowholes, the same way as does silicon in steel. (*b*) If aluminum really prevents the presence of blowholes, then its presence would be of advantage, as it would make the castings more solid; the addition of aluminum would not increase the durability of the castings.

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(229) (*a*) What gauge is used in measuring the thickness of sheet metals? (*b*) What books or articles would you recommend on the subjects of die making and the working of sheet metals?

E. J. W., Jackson, Mich.

ANS.—(*a*) Since July 1, 1893, the United States standard gauge has been the only gauge recognized by the U. S. Government. This gauge is given in Kent's "Mechanical Engineer's Pocket Book," page 31. (*b*) "The Press-Working of Sheet Metals," by Oberlin Smith, is a good book. There are numerous articles on these subjects in the back numbers of "The American Machinist."

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(230) What is the cause of the peculiar humming sound that telephone poles emit? I have been given several explanations, but they differ, and conditions are never similar. C. E. W., Jacksonville, Fla.

ANS.—It is due to the vibration of the wires, caused by the wind.

***

(231) Is street lighting a practical success on a 2,080,104-volt, 125-cycle, single-phase system, using the lamps connected to transformers already supplying current to incandescent lamps in houses?

L. B. P., Revelstoke, B. C.

ANS.—Street lighting on an alternating-current line, to be a pronounced success, would have to be done on a series system. Either of these can be used: alternating-current lamps connected in series to a "tub"; or direct-current lamps operated by a direct-current arc generator driven by an alternating-current motor. Direct-current lamps, supplied with rectified alternating current, may be used. The loss in transmission would be comparatively large on the plan you mention. Still, there is no doubt that you can make the proposed system a paying one.

***

(232) What is the difference between "mean low-water level in the Hudson river at Albany" and "mean sea level at Sandy Hook?"

F. W., Scranton, Pa.

ANS.—The height of the water in the ocean and in tidal rivers above any point near the shore is measured by automatic gauges, usually graduated to read feet and tenths of a foot. Readings are taken every hour (except when the weather is exceptionally stormy) for several months, and the mean taken. Then a shore line having an elevation, with respect to the point of reference, equal to this mean, is a "mean tide line" for the place.

If the place is on the seashore, the line is a "mean sea-level line." When we speak of elevations above mean sea level, we mean elevations above a horizontal plane intersecting the seashore in a mean sea-level line. If the lowest reading of the gauge is taken every day for some months, and the mean taken, a line having an elevation equal to this mean is a "mean low-tide line." If this line is used as a datum, elevations referred to it are spoken of as elevations "above mean low-water level," or simply elevations "above mean low water." Similar measurements are taken, and similar expressions used, when elevations are referred to the water level of lakes or non-tidal rivers.

* * *

(233) (*a*) What does it mean "to make a ditch bank at an angle of 36°"? (*b*) Can you refer me to some good books on ditch work? (*c*) How can I find a number which, if divided by 2, 3, 4, 5, or 6, will have 1 as a remainder, but which will contain 7 an exact number of times? F. H. T., Oak Harbor, Ohio.

ANS.—(*a*) Expressions like this are not technical expressions having a definite meaning. We speak of a slope of 2 to 1, of $1\frac{1}{2}$ to 1, etc., meaning 2 horizontal to 1 vertical, or $1\frac{1}{2}$ horizontal to 1 vertical, etc. But such expressions as "a 36° bank" must be further qualified, by stating the direction with which the bank makes an angle of 36°. Usually, however, slopes are referred to a horizontal plane, and in this case a bank at 36° means a bank making an angle of 36° with the horizontal, or having nearly a slope of $1\frac{1}{2}$ to 1. (*b*) We do not know of any special book on the subject, but you may find information in general works on civil engineering, drainage, irrigation, railroading, etc. (*c*) Let N be the number. Since this number does not contain any of the factors 2, 3, 4, 5, or 6, it is not divisible by any combination of them, nor by their least common multiple, which is $2^2\times 3\times 5$. We may, therefore, write $N = 2^2\times 3\times 5\times x + R$, where x is an integer and R a remainder less than $2^2\times 3\times 5$. In order that the remainders obtained by dividing $(2^2\times 3\times 5\times x + R)$ by 2, 3, 4, 5, or 6 $(= 2\times 3)$ may all be equal to 1, we must have $R = 1$. Further, as N is divisible by 7, we must have $N = 7y$, where 7 is an integer. Equating the two values of N, and putting $R = 1$, we get $60x + 1 = 7y$, whence $y = \frac{60x+1}{7}$. As both x and y must be integers, we substitute successively the values $x = 1, 2, 3$, etc., until we find an integral value for y. The value $x = 5$ gives $y = \frac{60\times 5+1}{7} = \frac{301}{7} = 43$. Having found these two values for x and y, the following pairs will also satisfy the conditions: $x = 5 + 7t$, $y = 43 + 60t$, where t is any positive integer. Thus, making $t = 0, 1, 2, 3$, etc., we get $y = 43, 103, 163, 223$, etc., and $N = 301, 721, 1{,}141, 1{,}561$, etc. Any of the numbers thus obtained will answer the question, which has, therefore, an infinite number of solutions. The least possible value of N is 301.

* * *

(234) What is your opinion as to the thermodynamic efficiency of an engine using alternately a charge of gasoline and a charge of compressed air in the same cylinder? Would the cooling action of the expanding air help to counteract the heating effect of the alternate charge of gasoline, and would the heating of the cylinder by the charge of gasoline increase the efficiency of the alternate charge of compressed air? C. J. T., Neponsit, Ill.

ANS.—We assume that you mean by the expression "charge of gasoline," a charge of mixed gasoline and air. To some extent the expanding air would cool the cylinder, and the entering charge of compressed air would, of course, be heated by contact with the hot cylinder walls. Air being a poor conductor, however, the amount of heat absorbed would be small. So far as the efficiency is concerned, you must remember that the cooling of the cylinder is detrimental to efficiency, and if we could run the engine without cooling, we would be glad to do so. The use of the air, therefore, decreases the theoretical efficiency of the gasoline engine. On the other hand, the burning of the gasoline would, as you suggest, increase the efficiency of the compressed air. The action would be similar to that of the reheater used with a compressed-air engine. An engine using compressed air is in any case inefficient, and while your arrangement might possibly be used in place of the ordinary compressed-air engine, where the air is obtained from some central compressing station, it would surely be unwise to use power from the engine to compress the air for the engine. Such a scheme, it seems to us, would result in a considerable loss of efficiency compared with the ordinary gasoline engine. There is one difficulty you have probably not considered. In a gas or gasoline engine the clearance is necessarily 30 or 40 per cent., while in a compressed-air engine it should be very small, say, 3 to 8 per cent. Even if the use of gasoline and air alternately were theoretically economical, it would be difficult to reconcile these widely different clearances.

* * *

(235) What is the best ratio between the areas of the high-pressure and the low-pressure cylinders of a vertical inverted compound engine?
O. O., Mt. Pleasant, Vancouver, B. C.

ANS.—As to the *best* ratio, authorities differ very much. A common rule for two-cylinder compound engines is to make the ratio equal to the square root of the number of expansions.

* * *

(236) I purpose going into the electroplating business on rather a large scale. Can you tell me where I can get all the necessary apparatus and appliances, for silver, gold, and nickel plating?
J. R. B., Fredericksburg, Va.

ANS.—Write to The General Electric Co., Schenectady, N. Y., or to C. H. Basly & Co., No. 10 N. Canal Street, Chicago, Ill.

* * *

(237) In THE MECHANIC ARTS MAGAZINE, February, 1899, Answers to Inquiries, No. 11, the following question is asked: In a boiler 30 inches in diameter by 10 feet long, in which there are twenty-two 3-inch tubes, what area of heating surface should there be? The answer given is 108 square feet; now, according to my calculation, twenty-two 3-inch tubes 10 feet long have far more than 108 square feet of heating surface. Does it change the meaning of the question to make it read thus: In a boiler, etc., how many square feet of heating surface *are* there. This is what I understand the question to mean.
R. A. T., Seattle, Wash.

ANS.—The value given is incorrect, as you state, and is a misprint. We make the heating surface of the tubes about 160 square feet, and that of the shell, 48 square feet, a total of 208 instead of 108 square feet. The question probably means, "how many square feet of heating surface are there?"

* * *

(238) Where can I obtain a copy of the engineers' license law recently passed in Pennsylvania?
L. L. R., Wetmore, Kas.

ANS.—Write to the Secretary of State of Pennsylvania, Harrisburg, Pa.

* * *

NOTE.—The Kingsford Foundry and Machine Works, Oswego, N. Y., would like to communicate with A. B. C., of New York, who asked question No. 172 in the August number of this magazine.—ED.

SELF HELP

LINCOLN WAS THOROUGH.

EDUCATION has been truly defined as a second birth. Much is said of the force of accident in directing the pursuits of men. Francis Wayland writes that he does not believe much in this "force-of-accident theory."

Men whose propensities are strong toward any particular course, can rarely live long without having those propensities quickened into action. The accident shows the bias of the mind, but does not create it. The proportion of men who have such propensities is comparatively small. But every man may make acquisitions which will render him respectable and useful, if he will only resolutely set himself about it.

It was at his mother's knee that Abraham Lincoln first learned to read. The three books he first absorbed were the Bible, Æsop's Fables, and Pilgrim's Progress; and from these three books was formed the literary taste of the future President. So diligent and masterful was his study of these books that he could repeat from memory whole chapters of the Bible, all the striking passages of Bunyan's immortal book, and every one of the fables of Æsop. The "Life of Henry Clay," procured for him by his mother, was his fourth book and one of his choicest treasures. Ramsey's "Life of Washington" and another on the same subject by Weems, were, at long intervals, added to his scanty stock of books. Whenever he heard of a book that could be borrowed, or read on the premises of the owner, there he went and never rested until the contents of the book had been absorbed.

Reading with young Lincoln begot a strong desire to write, and paper being a luxury almost out of reach of the pioneer children of these days, he smoothed shingles or took the smooth side of a wooden shovel, and composed thereon essays on topics of the time, and occasionally even tried verse-making. The scarcity of writing material taught him conciseness. Many words could not be used when writing was done with a clumsy piece of charcoal on a shingle. Severe, indeed, was the school in which the future President of the United States acquired that habit of condensing thought for which he was afterwards famous.

His stepmother said of him: "He read everything he could lay his hands on, and when he came across a passage that struck him, he would write it on boards, if he had no paper, and keep it by him till he could get paper. Then he would copy it, look at it, commit it to memory, and repeat it." He collected in this way a great many things from books he did not own and could not keep, and at the age of ten he had compiled a "commonplace book" in which were written the noble thoughts and melodious lives of famous men. Later, when he was yet but a callow youth, some of his literary productions were considered worthy of reproduction in the county newspaper. Of schooling, properly speaking, he had but very little, but when a schoolmaster came occasionally into the neighborhood, perhaps miles away, the little brood of children—Abraham, his sister, and his cousin Dennis—trudged through wildwood or through the snow to the log schoolhouse.

When seventeen years of age, he walked a long distance to attend court, where he heard one of the famous Breckinridges of Kentucky deliver a notable speech in a murder trial. This speech stirred the dominant genius in the lad's soul, and from that day he practiced speechmaking. Taking up any topic uppermost in the rural neighborhood, road building, laying out trails, school tax, bounties on wolves or bears, he "speechified," as he called it, to the gaping rustics that flocked to hear him. Sometimes he got up a mock trial and arraigned an imaginary culprit, acting himself as prosecuting attorney, counsel for the defendant, judge and jury, and going through all the forms and addresses of a regular court.

One notable thing about Lincoln was that when he began to study anything he was never satisfied until he had got to the root of it. He wrote and rewrote all that he wanted to commit to memory. No difficult problem would he abandon; and whenever he encountered a fact that to him seemed inexplicable, he never rested until it was

made clear and he had mastered its secret. He was in all things thorough. Years afterward, when he was President, a person came to him with a story of a plot or conspiracy, advancing little or no proof in support of his statements. Lincoln said: "There is one thing I have learned and you have not. It is only one word—thorough." Bringing his hand down forcibly on the table to emphasize his meaning, he repeated, "*Be thorough.*"

CULTURE AND TRAINING.

CULTURE and scientific training for a practical man, should be the purpose of all schemes of education of the individual citizen. Their order and extent, and their relative importance and magnitude, must, however, depend on the position in life of the individual; rather, on his choice than on their own logical sequence. The proper and logical order would be, first, culture, then professional training: first, the awakening and strengthening of the mind; next, its application to the purposes of culture; then its practical employment in acquiring and practicing the chosen vocation, whether that of the engineer who builds, the artist who adorns, the man of letters who entertains and enlightens, the jurist who interprets the law, or the physician or clergyman who ministers to bodies or to minds diseased, or even that of the man of leisure whose profession is that of the accomplished man of a society of culture. Every intelligent citizen desires for his children so much of culture as his time and means permit him to give them; his means determine to what extent he must abridge the culture studies, and compulsorily antedate the best time for entrance on the studies having practical application in the life of the bread winner. For people of wealth, twenty years of culture, five of professional study, may be none too extensive a course; but the citizen of moderate means must at least terminate his son's studies at twenty-one, and if he is to have a professional training, it must commence at sixteen or seventeen; while those who have to work for a living must send their offspring out into the world to earn their own living while still children. It thus happens that the education of the people must, in the main, be such as will give them technical training, with, incidentally, so much of culture as can be offered without detriment to their preparation for the work that must engage their life's attention. There is no culture unless it teaches us how to live.

To live is to have justice, truth, reason, devotion, probity, sincerity, common sense, right, and duty welded into the heart. To live is to know what one is worth—what one can do, and should do. Life is conscience.

> Life is a sea—as fathomless,
> As wide, as terrible, and yet sometimes
> As calm and beautiful. The light of heaven
> Smiles on it, and 'tis decked with every hue
> Of glory and of joy. Anon dark clouds
> Arise, contending winds of fate go forth,
> And Hope sits weeping o'er a general wreck.
> And thou must sail upon this sea, a long
> Eventful voyage. The wise *may* suffer wreck,
> The foolish *must.*

THE POTENCY OF STEAM.

IN COMPARISON with the past, what centuries of improvement has this single agent comprised in the short compass of fifty years! Everywhere practicable, everywhere efficient, it is an arm a thousand times stronger than that of Hercules, and to which human ingenuity is capable of fitting a thousand times as many heads as belonged to Briareus. Steam is found in triumphant operation on the seas; and under the influence of its strong propulsion, the gallant ship

> "Against the wind, against the tide,
> Still steadies with an upright keel."

It is on the rivers, and the boatman may repose on his oars; it is on the highways, exerting itself along the courses of land conveyance; it is at the bottom of mines, a thousand feet below the earth's surface; it is in the mill and in the workshops of the trades. It rows, it pumps, it excavates, it carries, it draws, it lifts, it hammers, it spins, it weaves, it prints. It seems to say to men, "Leave off your manual labor, give over your bodily toil; bestow but your skill and reason to the directing of my power; and I will bear the toil—with no muscle to grow weary, no nerve to relax, no breast to feel faintness." What further improvements may still be made in the use of this astonishing power it is impossible to know, and it were vain to conjecture. What we do know is, that it has most essentially altered the face of affairs, and that no visible limit yet appears beyond which its progress is seen to be impossible. If its power were now to be annihilated, if we were to miss it on the water and in the mills, it would seem as if we were going back to rude ages.

COLONEL ALBERT A. POPE.

ONCE A MARKET BOY—NOW A MILLIONAIRE BICYCLE MANUFACTURER.

THE career of Col. Albert A. Pope, of Boston, illustrates the saying: "Do not serve money, but use money as a lever to help you serve something greater than yourself."

Albert Augustus Pope comes from good New England stock, and was born in Boston, May 20, 1843. His father, Charles Pope, of Boston, was an active and energetic business man. Unexpected reverses, however, reduced the family to such straightened circumstances that young Pope was, at the age of nine, obliged to begin the struggle of life and learn those valuable lessons of perseverance and courage which have proved the foundation of his extraordinarily successful career.

The first work in which he engaged was done for a farmer in Brookline, near where his own family was then living. He went to school mornings, but gave his time in the afternoons and during all his vacations to the farmer. He was, says Manley M. Gillam, a boy who never shirked duty, and he made opportunity his servant. While yet not more than ten, young Pope began to buy fruit and vegetables from the farmers on his own account. He made his purchases in the afternoon and delivered the goods to his customers before school hour in the morning. He was from the start a success in business. He soon hired his father's horse and market wagon, and with his fresh fruit and vegetabies for sale became a noticeable figure in the lower part of Boston. His business grew so fast that he had to employ other boys to help him, and so well did he manage his affairs that in one season he had saved one hundred dollars. He paid every debt on time, and thus won the regard of every one with whom he was brought in contact. He kept, even in these boyhood days, a careful account of his expenses, and knew how every cent of his money was applied. How helpful is this practice? How many young men who let their money slip through their fingers ask themselves where has that money gone? They have no value for it. Would not the keeping of an itemized account of expenditures help them as it did Mr. Pope in giving him a due regard for money's value? It is interesting in his career to know that his expenses for one month, at this time, reached the sum of twenty-one cents, for another eighteen, and for still another fourteen, and yet he always had money at command and in his possession. Here we have the secret revealed of Colonel Pope's success — he never spent what he did not have, and just as little as possible of what he happened to have in his possession.

COLONEL ALBERT A. POPE.

Even now, after giving hundreds of thousands to charities and benefactions of various kinds, and surrounding himself with all the requirements of cultured life, Mr. Pope is a stern disapprover of waste and extravagance.

At the age of fifteen he left the high school to secure employment in the Quincy market. He was advancing, but in the face of great trial and difficulty. He rode back and forth with his employer every morning before sunrise and every evening after sundown in an open wagon, encountering the severest weather and never shirking from the most fatiguing tasks. Later on we find him working for four dollars a week for a firm of dealers in shoe-findings. There he did all the work of a porter, carrying one-hundred-pound bales, and stirring varnish for hours in uncomfortable quarters under the sidewalk.

His fidelity was so marked in the discharge of these laborious and trying duties that his salary was soon increased to five dollars a week, a considerable sum in those days.

The outbreak of the Civil War called young Pope into the service of his country. He was, at the beginning of hostilities, chosen captain of the Home Guard of Brookline. He applied himself with zeal to the study of military affairs, and soon became thoroughly familiar with the military tactics of the day. At nineteen he enrolled in the volunteer forces of the Union Army, and was sent to the front as second lieutenant in the 35th Massachusetts Volunteers. This was in 1862. His regiment was not long in the service before he became first lieutenant, and was soon after promoted to a captaincy. His chief battles were South Mountain, Antietam, Sulphur Springs, Fredericksburg, Vicksburg, Jackson, Missouri, Knoxville, Petersburg, and Poplar Springs Church. At Knoxville he received a wound. He was frequently employed by his commanding officer on important services, and acted as commander of his regiment on many occasions when the colonel was absent or disabled. For gallant conduct at the battle of Fredericksburg he was breveted major, and for still further distinguished conduct at Knoxville, Poplar Springs Church, and in front of Petersburg, made a lieutenant-colonel. His habits of forethought and economy stood him in such good stead while in the army that he left the service with over $3,000 in cash to his credit.

In 1876 he first saw a bicycle at the Centennial Exposition, and became fascinated with its mechanism. Convinced that there was a great future for this novel vehicle, he identified himself with its production. Starting from very humble beginnings in 1878, he has built up an extraordinary business with a capital of more than $5,000,000. Under his control are four factories at Hartford, Conn. These factories cover 18 acres of floor space, give employment to more than 3,000 expert mechanics, and have an enrollment of 3,800 expert agents. The productive capacity of the factories is more than 600 bicycles a day.

Besides being president of the Pope Manufacturing Company, Colonel Pope is a director in some of the largest financial concerns in the country. He is a prominent member of various military, educational, athletic, and commercial associations, and an officer or director in a score of other corporations. He has, for many years, steadily declined political honors. Colonel Pope married, September 20, 1871, Abby, daughter of George and Matilda (Smallwood) Linder, of Newton, Mass. They have four sons and a daughter. Besides his industrial enterprises, Colonel Pope directs the publication of that valuable periodical, "Outing," issued in the interests of wheelmen, and has, through its columns and otherwise, rendered the cause of good roads throughout the country inestimable service. Through his untiring efforts the Congress of the United States and the Legislatures of many States, aroused from their lethargy, have adopted measures tending in the right direction.

The press of the country, following the lead of Colonel Pope, has generously advanced the interests of this great practical reform with the result of inaugurating a movement which will, it is confidently expected, result in our having good roads throughout the country.

The success achieved by Colonel Pope is no mystery. He has ever loved work and deprecated waste. He has shrunk from no labor, and has placed true value upon time.

LEARN TO WAIT.

THERE is an element of success, which, in our age of rapid movement and change, is liable to be undervalued. We refer to patience and that capacity to wait for remote results, so essential to the achievement of anything worthy and enduring. Perhaps nothing is more characteristic of our American life than the intense desire to obtain wealth, reputation, honor, and office by rapid and short-hand processes. In business it leads men to take risks on the capital of others, to disregard the laws of morality, that fortunes may be made without work or waiting. In public and professional life it induces men to put office before honor, reputation before character, and is a prolific source of all sorts of counterfeits. It caters to unsound notions of public instruction. It demoralizes literature. We warn against the tendencies of this impatient age, if desire to secure solid and lasting success is sought. Do not attempt to secure success without the expenditure of labor, thought, and time. "Patient continuance in well-doing" is one of the chiefest virtues, and an essential to success. If you think to evade this law you will find your mistake.

SLOW AND SURE THE WINNER.

DOCTOR ARNOLD said of boys, that the difference between one boy and another consists not so much in talent as in energy. This is equally true of men. Given, perseverance, energy soon becomes habitual. Provided the dunce has persistency and application, he will inevitably head the cleverer boy devoid of these qualities. Slow but sure wins the race. It is perseverance that explains how the position of boys at school are so often reversed in real life; and it is curious to note how some clever at school have, after leaving it, become so commonplace, while others, dull boys, of whom nothing was expected, slow in faculty, but sure in pace, have assumed the position of leaders of men.

The writer, when a boy, stood in the same class with one of the greatest of dunces. One teacher after another tried his skill on him and failed. Corporal punishment, the fool's cap, coaxing, and earnest entreaty, all alike proved fruitless. The experiment was sometimes tried of placing him at the top of his class, and it was curious to note the rapidity with which he gravitated to the inevitable bottom. The youth was given up by his teachers as an incorrigible dunce—one of them pronouncing him "a stupendous booby." Yet, slow though he was, this much-condemned youth had in him a sort of dull energy of purpose, which grew with his muscles and his manhood; and, strange to say, when he at length came to take part in the practical experiences of life, was found heading most of his school contemporaries, eventually leaving the greater number far behind. In time he became the chief magistrate of his native city.

U. S. Grant, the illustrious American soldier, who suppressed the rebellion of the slave-holding States, was, when a boy, considered dull and unhandy. Stonewall Jackson, Lee's greatest lieutenant, was in his youth chiefly noted for his slowness. While a pupil at West Point Military Academy, Jackson was, however, equally remarkable for indefatigable application and perseverance. When a task was set him, he never left it until he had mastered it. "Again and again," wrote one who knew him, "when called upon to answer questions in the recitation of the day, he would reply, 'I have not yet looked at it; I have been engaged in mastering the recitation of yesterday or the day before.' The result was that he was graduated the seventeenth in a class of seventy. There was not, it is probable, in the whole class a boy to whom Jackson was not inferior in knowledge and attainments. But at the end of the race, he had only sixteen before him and had outstripped not fewer than fifty-three. It used to be said of him by his contemporaries that if the course had been for ten instead of four years, Jackson would have been graduated at the head of his class."

YOUNG MEN AND YOUNG BRAINS.

MR. PHIL. ARMOUR, who does a business of a hundred millions a year, was asked recently if he thought the chances for young men as good today as they were when he was young. "Yes," he said, "I think so. The world is changing every day, and new fields are constantly opening. We have new ideas, new inventions, new methods of manufacture, and new ways today everywhere. There is plenty of room for any man who can do anything well. The electrical field is a wonderful one. There are other things equally good, and the right man is never at a loss for an opportunity. Provided he has some ability and good sense to start with, is thrifty, honest, and economical, there is no reason why any young man should not accumulate money and attain success in life."

When asked to what qualities he attributed his own success, Mr. Armour said: "I think that thrift and economy had much to do with it. I owe much to my mother's training and to a good line of Scotch ancestors, who have always been thrifty and economical. As to my business education, I never had any. I am, in fact, a good deal like Topsy, 'I just growed.' My success has been largely a matter of organization. I have always made it a point to surround myself with good men. I take them when they are young and keep them just as long as I can. Nearly all of the men I now have, have grown up with me. Many of them have worked with me for twenty years. They have started in at low wages, and have been advanced until they have reached the highest positions." Mr. Armour thinks that most men who accumulate a large amount of money inherit the money-making instinct. The power of making and accumulating money, he says, is as much a natural gift as are those of a singer or an artist. "The germs of the power to make money must be in the mind. Take, for instance, the people we have working with

us. I can get millions of good bookkeepers or accountants, but not more than one out of five hundred in all of those I have employed has been a great success as an organizer or trader."

Mr. Armour is a great believer in young men and young brains. He never discharges a man if he can find him other work. He will not, however, tolerate intemperance, laziness, or getting into debt. Some time ago a policeman entered his office. In answer to Mr. Armour's question, "What do you want here?" he replied: "I want to garnishee one of your men's wages for debt." "Indeed," said Mr. Armour, "and who is the man?" Asking the officer into his private room, he sent for the debtor. "How long have you been in debt?" asked Mr. Armour. The clerk replied that he had been behind for twenty years and could not seem to catch up. "But you get a good salary, don't you?" "Yes, but I can't get out of debt." "But you must get out, or you must leave here," said Mr. Armour. "How much do you owe?" The clerk gave the amount, which was something less than a thousand dollars. "Well," said Mr. Armour, handing him a check, "there is enough to pay all your debts, and if I hear of your again getting into debt, you will have to leave." The clerk paid his debts and remodeled his life on a cash basis.

PAST AND FUTURE.

THERE are two thoughts that it would be well to recall at the close of any important action or occasion of our lives. One is, that it is gone beyond recall. It belongs to the past, and has thus been taken out of our hands. We may regret it, but we cannot undo or reverse it; therefore, to continue vainly to deplore it is waste of life and energy. We may rejoice in it, but, as it is finished, we must press on to something else.

The other thought is, that, whatever it may be, it bears a lesson for the future. In it we may find some secret of success or of failure, some suggestion of better methods or untried plans, some new means of advancement, some message of sympathy or kindliness to others. For this purpose it is worthy of contemplation; but, when this is gained, we should hold life too precious, too full of work and of duty, to dwell either in deploring it, or in exulting over it.

Leave what you've done for what you have to do;
Don't be "consistent," but be simply true.

BRAINS SECOND TO WILL.

BRAIN itself is second in importance to will. The vacillating man is always pushed aside in the race of life. It is only the weak who halt before adverse circumstances and obstacles. What we long for and strive for with all our strength, we usually approximate if we do not fully reach. Hunger breaks through stone walls; stern necessity will find a way or make one.

There is as much chance of idleness and incapacity winning real success, or a high position in life, as of producing a Paradise Lost by shaking up promiscuously the separate words of Webster's Dictionary, and letting them fall at random on the floor. Fortune smiles on those who roll up their sleeves and put their shoulders to the wheel; on men who are not afraid of dreary, dry, irksome drudgery, men of nerve and grit who do not turn aside for dirt and detail.

We must learn that "he alone is great who, by a life heroic, conquers fate;" that "diligence is the mother of good luck"; that, nine times out of ten, what we call luck, or fate, is but a mere bugbear of the indolent, the languid, the purposeless, the careless, the indifferent; that the man who fails, as a rule, does not see or seize his opportunity.

So nigh is grandeur to our dust,
So near is God to man,
When Duty whispers low, "Thou must,"
The youth replies, "I can."

What a mighty will Napoleon had. Nothing ever daunted him. All through the Russian expedition, one of the most frightful experiences in history, he was calm, self-possessed, self-controlled, self-centered, ever believing in his destiny, and without diminution of courage. Misfortune, disaster, obstacles, and sorrows that would crush and unbalance ordinary minds, did not disturb his serenity. When soldiers of all ranks were blowing their brains out by the score to escape misery, when the men were staining the snow with their blood, he never faltered, but cheered them and inspired them with hope and confidence in himself. And even in this extremity, when men were driven to desperation and reduced almost to starvation, they would have died for the Emperor if it had been necessary.

"Nature seems to have calculated," said he, "that I should endure great reverses. She has given me a mind of marble; thunder cannot ruffle it; the shafts merely glide along."

STUDENTS WHO HAVE BENEFITED THEMSELVES

THROUGH HOME STUDY

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FROM PIT BOSS TO MINE INSPECTOR.

I have read and studied textbooks for twenty-five years, and from them I gained much information, but I gained more practical and essential information from the Instruction Papers of your School in one year than I did from the textbooks. When I enrolled in the Schools I was a pit boss, and candidly admit that without their aid I never could have obtained my position. In January, 1895, I was awarded 99½ per cent. in an examination for State Mine Inspector, and in due time was appointed by the Governor. I appointed Mr. John D. Jones, of Rockvale, who is also a student in the Schools, as my deputy.—*David Griffiths, Mine Inspector, Newcastle, Colo.*

BECOMES ASSISTANT SUPERINTENDENT.

I owe so much of my success to the Schools that I take pleasure in stating that, on finishing my Course in Heating and Ventilation, I was promoted to the position of Assistant Superintendent of the Germantown Steam Company, which position I still hold. I consider the instruction received through the Schools to have been of inestimable value to me, and would say that the eight students I have enrolled have voiced these sentiments to me many times. I would advise any young man who is in a position to take one of your Courses to do so by all means.—*C. O. Allen Maule, Assistant Superintendent, Germantown, Pa.*

SECURES A GOOD POSITION.

As I was ambitious to become a stenographer, I enrolled in the Complete Stenographic Course on the 4th of February, 1898, and was granted a diploma on the 20th of February, 1899. I was greatly benefited by the Course, as the Instruction Papers are so clear and plain that any person of average attainments, who is willing to study, cannot help but learn. A short time after I received my diploma I was offered a position in the office of The Lanyon Zinc Company, of this place, at a fair salary, with an increase of wages after I had acquired some experience. I at once accepted the position and am getting along nicely. I will ever be ready to help the Schools.—*Mary Wilson, Stenographer, Iola, Kansas.*

NOW DIVISION MASTER MECHANIC.

I have just completed the Locomotive Engineering Course of the Schools, and have enrolled in the Electrical Engineering Course. I have found the system of instruction very systematic and complete. The Instruction Papers treat the various subjects in a very exhaustive manner, and the faithful student cannot fail to receive a thorough education in the subject studied. I have been benefited very much since I became a student in the Schools, and now have a responsible position as master mechanic of the Central Railroad Company of New Jersey.—*J. S. Chambers, Division Master Mechanic, Elizabethport, N. J.*

POSITION AND SALARY ADVANCED.

I went to work when quite young, having only a common school education. I am employed in the Graton & Knight Mfg. Co.'s tannery, and as the modern tanner must be something of a chemist, I enrolled in the Organic and Inorganic Chemistry Course. Since studying in the Schools I have been placed in a more responsible position and receive a corresponding increase in salary. I have frequent occasion to use my chemistry, and expect to advance still further in the future. From the workingman's standpoint, I consider the Course equal to, or superior to, a regular college course.—*P. H. Wight, Tanner, Worcester, Mass.*

WHEELWRIGHT BECOMES DRAFTSMAN.

For fifteen years I worked at the bench as a wheelwright.

Two years ago I enrolled in the Complete Mechanical Course of the Schools, and applied myself to study. A short time ago the Schools' agent in Harrisburg, Pa., secured for me an excellent position in the drafting department of the Harrisburg Foundry and Machine Works.

In view of the facts that I had absolutely no experience in drafting but what I received from the Schools, and that I am well able to do the work in the drafting department to the satisfaction of my employers, I consider the methods of instruction the very best that any man can obtain to fit himself for a useful place in the world. The Schools have done more for me than I can find words to express, and I shall ever prize very highly the suggestion that induced me to enroll.—*Edwin F. Dornbach, Draftsman, Harrisburg, Pa.*

GENERAL FOREMAN GREATLY BENEFITED.

I enrolled in the Mechanical Drawing Course of the Schools in April, 1895, having no knowledge whatever of mechanical drawing. I completed the Course in March, 1898, and now feel qualified to handle any line of drafting in connection with this business. I was so much pleased with my studies and the attention received from the Schools that I enrolled in the Complete Mechanical Course, and am making very satisfactory progress in the same. My studies have been of great benefit to me in my position as General Foreman of the Car Department of the Lake Shore and Michigan Southern Railway. The International Correspondence Schools present an opportunity for education that should be grasped by all who can study only in spare time. I keep all my drawings at my office and will gladly show them to prospective students.—*R. W. Burnett, General Foreman, Englewood, Ill.*

REPAIRMAN BECOMES FOREMAN.

I cannot say too much in praise of The International Correspondence Schools and the excellence of their Instruction Papers. They are very thorough, being not too hard, nor yet too easy, but just right, making it possible for any one to understand them. When I enrolled in the Electrical Engineering Course I was a repairer of electric cars. I advanced in succession to wireman, dynamo-tender, general electrician, and am now electric shop foreman with the Brooklyn Rapid Transit Company. I am now finishing the balance of my Course, and can see advancement and prosperity ahead.—*H. Edward Keffer, Foreman, 376 Palmetto St., Brooklyn Borough, N. Y.*

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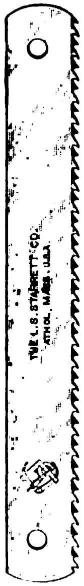

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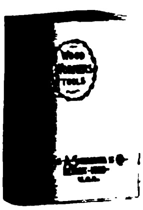

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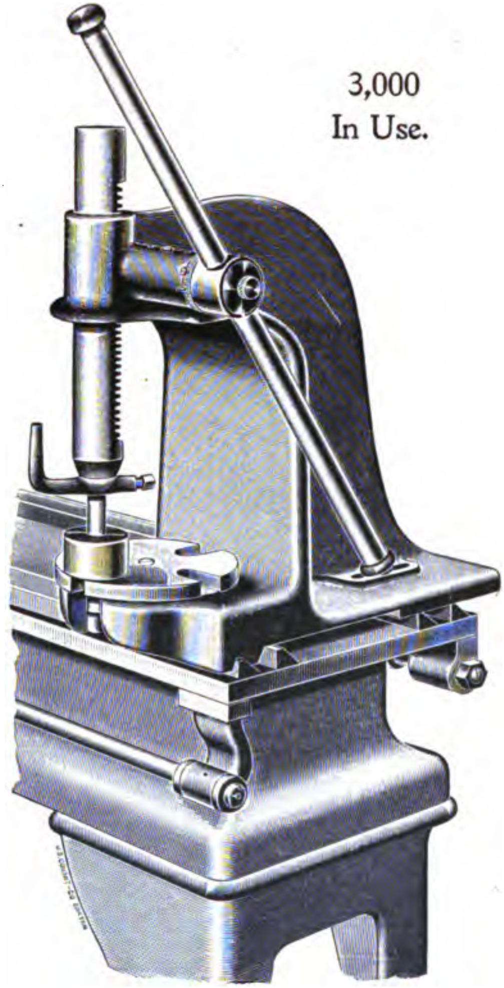

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THE MECHANIC ARTS MAGAZINE.

Vol. IV. OCTOBER, 1899. No. 9.

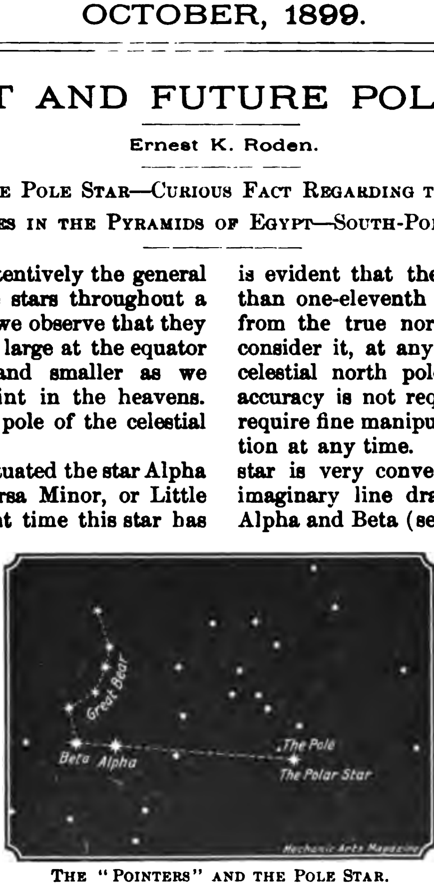
PRESENT AND FUTURE POLE STARS.

Ernest K. Roden.

THE IMPORTANCE OF THE POLE STAR—CURIOUS FACT REGARDING THE ARRANGEMENT OF THE PASSAGES IN THE PYRAMIDS OF EGYPT—SOUTH-POLE STAR.

BY EXAMINING attentively the general movements of the stars throughout a clear, dark night, we observe that they describe circles that are large at the equator and become smaller and smaller as we approach a certain point in the heavens. This point is the north pole of the celestial equator.

Close to this pole is situated the star Alpha in the constellation Ursa Minor, or Little Bear, and at the present time this star has the distinction of being the pole star, or, in other words, the approximate center around which all other stars seemingly rotate. The pole star is, however, not exactly at the celestial pole; it deviates from it by an angular distance of about 1° 15′, and has a small but sensible motion around it, as well as a secular motion that cannot be detected without years of laborious observations.



THE "POINTERS" AND THE POLE STAR.

Twice in twenty-four hours the pole star is at its maximum distance of 1° 15′ from the pole; at all other times it is less than this, and twice in twenty-four hours its bearing indicates true north—once at its upper and once at its lower culmination. In other words, the star indicates true north when it is situated either vertically above or vertically below the pole. From this it is evident that the star never varies more than one-eleventh part of a compass point from the true north; hence, it is safe to consider it, at any hour, as indicating the celestial north pole in cases where great accuracy is not required. It would indeed require fine manipulation to detect a variation at any time. The position of the pole star is very conveniently indicated by an imaginary line drawn between the stars Alpha and Beta (see figure) of the constellation Ursa Major, or Great Bear. This line, when extended northward for about 4½ times its own length, will almost touch the pole star. Hence, the Great Bear affords an infallible guide to the pole star, and the two stars Alpha and Beta are called the "pointers" from their peculiarity of pointing out, to astronomers as well as navigators, so important a star.

Our present pole star, however, did not always, and will not forever, bear the distinction of being the most important among the stars in the northern celestial hemisphere. Owing to the motion of the pole, it will, in course of time, about 2095 A. D., approach to within 28′ from the north pole and will then commence to recede from it. At the time of Hipparchus (156 B. C.) it was 12°, and in the year 1785 it was 2° 2′ distant

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from the north pole. Two thousand years ago the star Beta of the constellation Ursa Minor was the pole star, and about 2,300 years before the Christian Era the star Alpha of the constellation Dragon was not more than 10′ from the pole, while 12,000 years after the present time the brilliant star Vega of the constellation Lyra will be within 5° of it. These changes, requiring hundreds of years, are caused by what is known as "The Precession of the Equinoxes," which means the gradual movement of the equinoxes toward the west.

A remarkable fact in connection with the building of all the great pyramids of Gizeh, Egypt, is that the narrow passages or tunnels, by which alone they can be entered, all open out on the north sides of the pyramids, and these passages or tunnels are inclined, or slope, at an angle allowing the then pole star (Alpha, Dragon) to be visible to an observer stationed at the bottom of the passage. It is probable that these passages were arranged for the purpose of observing the transitions of the then pole star.

The importance of the pole star is not merely its indication of the true north and south, thus pointing out the variations of the compass needle, but it also serves another purpose, namely, that of obtaining the latitude at any time of the night by an inconsiderable amount of figuring — something which cannot be accomplished by any other star.

If the pole star were situated exactly at the pole, the latitude could be obtained by the simple measurement of its altitude. In other words, the mere measurement of the star's true altitude would give at once the latitude of the observer; so that, if an altitude of 30° was obtained, the latitude of the observer would be 30° N.

As to the distance of the present pole star from the earth, it may be mentioned that its light requires about 44.6 years to reach the earth, notwithstanding the fact that light dashes along with such inconceivable speed that it will cover 185,000 miles per second.

The light from Vega, the next pole star, requires 18 years to traverse the distance between it and the earth. As a consequence, we do not see the present pole star as it is at the present time, but as it was 44.6 years ago. Indeed, if the pole star were blotted out from existence today, it would still continue to shine out as vividly as ever for 44.6 years. So it is with all other stars, according to their distances.

The south pole of the celestial equator is not as favored as the north pole by the proximity of a bright star. The only star deserving the name of the south-pole star is one of the sixth magnitude, and consequently just about visible to the naked eye.

NEW METHOD OF EXTRACTING ROOTS.

"Spacer."

GEOMETRICAL PROGRESSION—THE ARITHMETIC MEAN—EXAMPLES ILLUSTRATING SQUARE, CUBE, AND FIFTH ROOT.

THE following method of extracting roots has recently been called to the attention of the writer. The method is so easily applied and remembered that the writer feels justified in offering it to the readers of this magazine. We will start with the fifth root.

Let n be any number and a its fifth root; then n is the last term, and a, the first term and also the ratio of a geometrical progression of five terms, which may be expressed by $a : a^2 : a^3 : a^4 : a^5$. Here a is the first term, a^5 (or n) is the last term, and a is the ratio. Since $n = a^5$, a is a factor of n, it is evident that, if we can resolve n into 5 equal factors, one of these factors will be the fifth root. Now, if we divide n into 5 factors, and find their arithmetic mean (the sum of the factors divided by the number of factors), the result will be the value of a,—exactly or approximately, according to whether the factors are equal or unequal. If the factors are unequal, the arithmetic mean will be larger than the true value of a, when the product of the factors is equal to, very nearly equal to, or exceeds the given number n, the amount of variation depending on the degree of inequality of the factors.

If, after having obtained the arithmetic mean, which we will designate by a_1, we assume it to be the value of the *ratio* of the progression, and divide n, the last term, by it, we shall obtain the value of a^4, the fourth term, approximately. Then, dividing this

value of a^4 by a_1, the result will be the approximate value of a^3. So proceeding, we finally obtain the approximate value of a, the first term, which we will designate by a'. In this operation we have used a_1 four times as a divisor; i. e., we have divided n by a_1^4. In other words, we have resolved n into 5 factors $a_1 \times a_1 \times a_1 \times a_1 \times a'$, and the new arithmetic mean,

$$a_2 = \frac{a_1 + a_1 + a_1 + a_1 + a'}{5},$$

will be nearer the true value of a than was a_1. By using a_2 as the value of the ratio and repeating the process, the next arithmetic mean, a_3, will be still nearer the true value of a.

We will now apply the method to a particular case. Suppose we wish to find the fifth root of 2,571. Call this number 2,500. This is equal to $5 \times 5 \times 10 \times 10 = 5 \times 5 \times 100 = 5 \times 5 \times 4 \times 4 \times 6$, nearly.

The arithmetic mean is

$$\frac{5 + 5 + 4 + 4 + 6}{5} = 4.8 = a_1.$$

$2,571 \div 4.8 = 535.625$; $535.625 \div 4.8 = 111.5885$; $111.5885 \div 4.8 = 23.2476$; $23.2476 \div 4.8 = 4.843 = a'$.

The arithmetic mean is

$$\frac{4.8 + 4.8 + 4.8 + 4.8 + 4.843}{5} =$$

$$\frac{4 \times 4.8 + 4.843}{5} = 4.8086 = a_2.$$

Repeating the process, carrying all results to 8 figures, we have

$2,571 \div 4.8086 = 534.66705$; $534.66705 \div 4.8086 = 111.18975$; $111.18975 \div 4.8086 = 23.123102$; $23.123102 \div 4.8086 = 4.8086973 = a''$.

The arithmetic mean is

$$\frac{4 \times 4.8086 + 4.8086973}{5} = 4.80861946 = a_3.$$

The exact root to 8 figures is 4.8086195; hence, a_3 is the correct value of a to 8 figures.

The process is essentially the same for other roots. Thus, for square root, the number would be divided into 2 factors; for cube root, into 3 factors; for the fourth root, into 4 factors; etc. Care should be taken to point off the number into periods, in the same manner as when extracting roots by any other method. If there are more than two periods in the given number, it would be well to use only the first two periods when obtaining the value of a_1, or, if the first period contains three figures or more, only the first period. Better results will be obtained, according as the original factors chosen approach equality. Examples illustrating square and cube root will now be given.

Find the cube root of 2,571.14. Pointing off into periods we have 2′571.′140. Considering the first two periods, and assuming them to be 2,500, $2,500 = 10 \times 10 \times 25$. It will be better to make the factors more nearly equal, the factor 25 being considerably larger than the other two. This may be done in several ways; we will give two.

First: $2,500 = 10 \times 10 \times 25 = 10 \times 250 = 10 \times 16 \times 15.6$ * $= 15.6 \times 160 = 15.6 \times 13 \times 12.3$ *; from which

$$a_1 = \frac{15.6 + 13 + 12.3}{3} = 13.6.*$$

Second: Choose a larger value for one of the two equal factors; square it, and divide 2,500 by the result. Thus, choosing 14, the square is 196; call it 200. Then, $2,500 \div 200 = 12.5$; $2,500 = 14 \times 14 \times 12.5$, nearly, and

$$a_1 = \frac{14 + 14 + 12.5}{3} = 13.5.$$

Either of these values may be used, but, since 2,500 is quite a little less than 2,571, we will use 13.6 for a_1. In obtaining the value of a_2, it is not necessary to use more than the first two periods, but nevertheless we use all the figures. $2,571.14 \div 13.6 = 189.054$; $189.054 \div 13.6 = 13.901+ = a'$.

Hence,

$$a_2 = \frac{13.6 + 13.6 + 13.901}{3} = 13.7001, \text{say } 13.7.$$

Repeating the process, $2,571.14 \div 13.7 = 187.67445$; $187.67445 \div 13.7 = 13.698865 = a''$. Hence,

$$a_3 = \frac{13.7 + 13.7 + 13.698865}{3} = 13.699622.$$

The exact root to 8 figures is 13.699622.

Had a_1 been taken as 13.5, the resulting value of a' would have been 14.107, and of a_2, 13.7023, a value slightly greater than that previously obtained. It is apparent that the nearer the values of a' and a_2 approach equality, the more nearly correct will the value of a_3 be; in fact, if there is considerable difference, it would probably be well to increase or decrease the value of a_1 slightly, and recalculate a_2.

We will now find the square root of 1,971.14. Pointing off into periods, we have 19′71.′14. Using the first two periods, and assuming them to be 2,000, $2,000 = 50 \times 40$. The arithmetic mean of the two factors is $\frac{50 + 40}{2} = 45$; 45, however, is a little too large, so we assume it to be 44 and divide

* Exact results are not required.

the first two periods by 44, carrying the result to 3 figures, obtaining $1{,}971 \div 44 = 44.8$. Hence, $1{,}971 = 44 \times 44.8$, nearly; and

$$a_1 = \frac{44 + 44.8}{2} = 44.4.$$

Now, using all the figures, $1{,}971.14 \div 44.4 = 44.395+ = a'$; and

$$a_2 = \frac{44.4 + 44.395}{2} = 44.3975.$$

Taking 44.397 for a_2 and repeating the process, $1{,}971.14 \div 44.397 = 44.398044 = a''$; hence,

$$a_3 = \frac{44.397 + 44.398044}{2} = 44.397522.$$

The exact root to 8 figures is 44.397522.

Since the values of a' and a_2 are very nearly equal, their fifth figures differing by less than 2½ units, we should have been justified in using 6 figures for a_2, and the resulting value of a_3 would have been correct to 10 or more figures—in this case, probably to 13 figures.

It is seldom necessary to carry the work to so many figures as has been done in the foregoing examples; it was so done here merely to show the accuracy of the method. In fact, if care be taken to make the values of a_1 and a' agree to 3 figures, the value of a_2 will be correct to at least 5 and generally to 6 figures, and it will not be necessary to calculate the value of a_3 unless greater accuracy is required.

ORNAMENTAL DESIGN.

Louis Allen Osborne.

NATURAL AND CONVENTIONAL DESIGNS—HOW TO STUDY FLOWERS—WHY NATURALISTIC FLOWERS AND FOLIAGE ARE NOT ALWAYS USED IN DESIGNS.

WHEN you look at the wall paper of a room, the carpet covering the floor, or the printed design of a calico dress or a silk waist, does it ever occur to you that, though the design is representative of roses, lilies, poppies, or other floral clusters, in reality they are a long way from a good counterfeit of the original article of nature? On the other hand, how often have you looked upon a painting of a bunch of bright-colored flowers in a vase and felt almost inclined to reach out and touch the canvas, so natural did they appear? Why, then, do we find one representation so like the original article and another one so different?

FIG. 1.

When we are told that the carpet design, the wall paper, and the calico print are *conventionalized* patterns, we learn little, and many a misguided man is today under the impression that the conventionalized design is simply a name applied to a class of ornament that does not strongly resemble what it is intended to represent.

This, however, is not true, as a little study of the conditions governing the art of ornamental design will soon convince us.

The object of this article is not to teach decorative design, but simply to suggest a few words of advice to those that may be contemplating its study and do not know where to begin, or to those of whom so many questions are often asked as to why designs are not made more "natural"; the former being of the class that may at some time

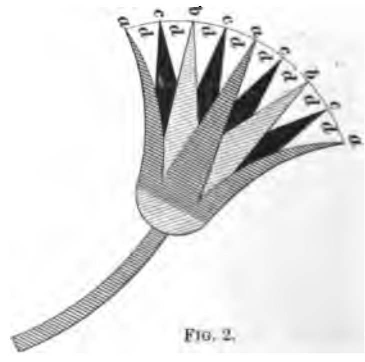


FIG. 2.

design the goods, and the latter of the class that must sell them to exacting and inquisitive customers.

In the first place, let us consider what constitutes an ornament. In its general

sense, an ornament is something to please the eye; it may be a colored bead, or a string of them, or it may be a finger ring or a bracelet, or it may be a flower worn in the hair or at the throat; such objects are ornaments pure and simple, and, practically, may be considered the most useless things on earth. However, they give us a certain sense of pleasure; they distract our minds from the continuous contemplation of more serious things, and therefore have their purpose in the world; but nevertheless, these objects, strictly speaking, are not products of ornamental design.

Ornament, in its nobler sense, consists of that which is added to, or developed from, objects of bare utility, to make them agreeable to the eye, and therefore beautiful. It is necessary that an object should first be useful before it comes before the mind of the decorative designer to be rendered beautiful. Ornamental or decorative design, therefore, is the art of rendering an article useful and beautiful at the same time. To return to our carpet, for instance; it is necessary that our floor shall be covered with some material that will deaden the noise, keep out the drafts, and not readily wear out in use; painted canvas or heavy burlap might serve that purpose, but how would it look? Our walls might be left in their plain brown mortar or with a dead-white coat, but what an unsightly surrounding. No! we cannot be happy under such circumstances, so we weave in our carpet fantastic patterns in which are blended many colors to please the eye. Our walls are papered or stenciled to represent a somewhat stiff geometrical ornament that can scarcely be distinguished a little way off, and over our doors and windows we hang draperies and blinds to subdue the light and add to the harmony of colors surrounding the room. The absolute necessities of health and comfort have been rendered beautiful by the art of decorative design.

FIG. 3.

Now, let us consider for a moment why we make the patterns for our designs conventional and why we frame and hang on our walls pictures that in many cases are as close a counterfeit of nature as they can be made. In the first place, the framed picture on our walls is an *ornament* pure and simple; its single purpose is to be beautiful—beautiful as a counterfeit of nature, or beautiful as the expression of individuality of the artist that painted it. Suppose that our wall paper has been designed with natural bunches of red roses or yellow goldenrod and the pattern repeated unlimitedly all around the room. Bright patches of red or yellow flowers and green leaves would be everywhere apparent all over the wall—the colors being out of harmony in some places with the surroundings, and the pictures hung on the wall looking ghastly by the contrast. Here we would have what purports to be a number

of bunches of flowers, and yet the very idea is contradictory, for no one ever saw two bunches of flowers exactly alike in shape, perfection, or color, and yet these bunches are as nearly identical as a printing machine

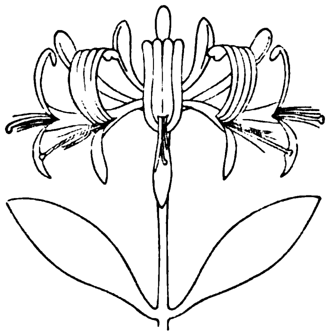


FIG. 4.

can make them. Therefore, our "natural" bunches of flowers are not as they would be in nature, and, paradoxical as it may seem, they are "unnatural." Moreover, it is impossible, with such a device, to deceive the eye into the belief that there are actual bunches of roses on the wall; they say plainly, "This wall is papered." No; a picture is a picture, and must be framed and treated as a picture, but our wall paper is for a practical purpose and its ornamental features must be governed accordingly.

Our carpet is a floor covering first and foremost, and if we weave into its fabric colored threads to represent a flower, we must make that a "woven flower," not a lying imitation of nature.

This reduction of flower forms to certain governable principles, sometimes geometric, and at others apparently unrestrained, is called conventionalism, and its successful interpretation is one of the most important talents in the designer's service. The ancient Egyptians and the Greeks carried conventionalism so far that in many cases it is with the utmost difficulty one can tell from what type the design is derived. Take, for instance, Fig. 1, which is an outline drawing of the Egyptian lotus blossom; the outside and most prominent leaves *a* are of a deep-green color, while the inner leaves *b* are purple at the tip, blending off to orange at *c* and to pure white at *d*. Compare this with Fig. 2, which shows the

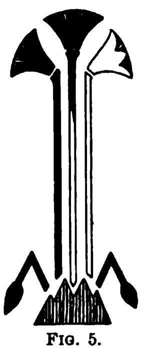


FIG. 5.

conventionalized lotus. Here the exterior leaves *a* are still dark green and are the most prominent detail of the design; the leaves *b* are green also, but of a lighter color, but the petals *c* are red and the background *d* is a deep yellow. No man would ever take Fig. 2 for a counterfeit imitation of Fig. 1, either in color or outline, and yet there is no doubt that it is intended for a conventionalized lotus blossom. The deep-green calyx characteristic of the flower is preserved in the conventional design. The purple, white, and orange petals that constitute the center of the natural blossom are replaced in the design by the primary colors, red and yellow, that make up the orange of the center, and the effect when viewed from afar is very much the same. The principal characteristics of the flower have all been retained in the conventional form, but all imitation of nature has been avoided. In Fig. 5 a still more conventional rendering of the flower

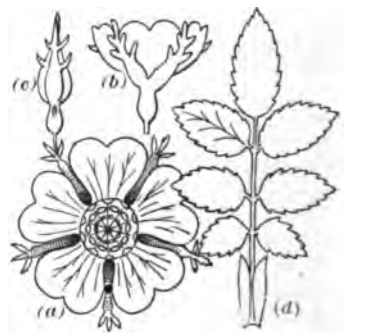


FIG. 6.

is seen. In this example, no color is used, and, therefore, all of the interior petals are omitted. The three characteristic exterior petals are retained, and the heart of the flower is rendered in a half tone. Many Egyptian wall paintings are decorated with lotus bands and borders whose conventionalized outline is as simple as Fig. 5.

Having thus considered the lotus in its natural and conventional outline, let us look at one of our local flowers and consider its possibilities in conventional design. In Fig. 3 is shown the natural honeysuckle vine and blossom. Now, what are its most striking characteristics? A little study of the flower shows us a cluster of long and somewhat pear-shaped buds, sometimes on the end of the same stem with a number of trumpet-shaped blossoms whose edges curl over, and from whose centers protrude a number of fine hair-like pistils. In fact,

this seems to describe all the characteristics of the flower, except, perhaps, that the open blossoms seem to be on the outside of the buds, those at the center opening last.

Fig. 4 shows us these characteristics arranged geometrically, and it requires but little imagination to recognize the blossom. All the characteristics are there arranged systematically in the order nature intended them. Thus, we have a conventional honeysuckle blossom. The study of animal, plant, and insect forms, for the purpose of embodying their characteristic features in a conventional design, requires that the designer shall give close attention to the subject he is to conventionalize. A general knowledge of structural botany enables him to accentuate those details of plant life that characterize the particular plant forming the theme of his design, without interfering with the mechanical details of the article's manufacture or with its utilitarian and ornamental purpose.

A good way to impress upon the memory these structural details is to draw the leaf and blossom out on geometrical lines and study each important detail of its formation as we proceed.

Fig. 6 shows such an analysis of the common dogrose. At (*a*) is a view of the flower, looking into its center, but the leaves are flattened out as though they had been pressed. At (*b*) is a geometrical side view of the blossom, showing the character of its outline. At (*c*) is a side view of the bud and its enclosing calyx, while at (*d*) is a spray of the pressed leaves, showing all their characteristic details.

A similar analysis can be made of any flower, and, once made, the structural knowledge so acquired is not easily forgotten.

Even though a person is not directly interested in the subject of ornamental design, it is a satisfaction and intellectual advantage to be able to read a design intelligently and comprehend the ingenuity displayed by the designer in the adoption of a flower or vine to the exigencies of the case in hand.

To paint a rose so realistic that one imagines he can almost inhale its perfume requires the inherent talent of the artist, but to design a rose pattern so that it may be woven, printed, or wrought, requires both the talent of the artist and the skill of the artisan.

The talent must be born in the man; it cannot be acquired, though we all possess it to some extent, but the skill and dexterity are details that are acquired by study and practice, and are thus within the reach of every one.

HELP FOR THE STRICKEN.

A STIRRING appeal has been made to the people at large by the Secretary of War of the United States for contributions, prompt and generous, in aid of the thousands of sufferers left homeless and in starvation by the recent disastrous hurricane which swept over Porto Rico. Accurate reports state that several thousand human lives were lost, hundreds of thousands of once happy homes were destroyed, crops were everywhere utterly ruined, and many thousands of human beings are literally starving for want of food. Hungry, houseless, with scarcely any clothing left to cover their nakedness, the unfortunate survivors are threatened with the additional horrors of a plague. Crowds of women, old men, and helpless little ones are encountered on every hand, piteously begging for food and shelter.

Over 90 per cent. of the houses have been demolished, and in many places the furious onset of the sea has swept away almost every vestige of flourishing little towns and villages. From Adjuntas, Guayamas, Zabucoa, Mayaguez, Maunabo, Arroyo, and other localities, the loss of life has been appalling.

Mayor Samuel H. Ashbridge and the Citizens' Permanent Relief Committee of Philadelphia have organized a Citizens' Porto Rico Relief Fund, and our readers are asked to contribute to it and to send their contributions either to Hon. Samuel H. Ashbridge, Mayor of Philadelphia, or to Messrs. Drexel & Co., Treasurers Porto Rico Relief Fund, Fifth and Chestnut Streets, Philadelphia.

The Secretary of War has assigned the United States auxiliary cruiser "Panther" to Philadelphia, from which port she will sail, loaded with the food, etc. donated by the big-hearted men, women, and children of Pennsylvania, who have never failed to respond, heartily and liberally, to the appeal of the distressed.

All contributions of money, however small, will be gladly received and acknowledged.

DESIGNING MACHINERY.

D. Petri-Palmedo.

NOTIONS — ARTISTIC DESIGNS — TWO IMPORTANT RULES — DETAILING — PENCIL DRAWINGS. SYMMETRY IN DESIGN.

PART IV.

A GREAT deal more could be said about alterations, such as have been made examples of in the previous articles, and in which the strength and properties of material are, largely, the determining factors. The subject of frames is a special study in itself, a very instructive, and, therefore, paying one for the student to follow up. We have seen it involve laborious work, which, however, growing familiarity with the subject greatly lightens, as the progressing designer will acquire gradually what may properly be termed "notions" on the proper shape and strength of machine parts that will enable him to hit pretty close to the final results at the first guess, making repeated calculations unnecessary. Such notions constitute a great portion of the experience of the designer, and it is remarkable how close an experienced man will estimate.

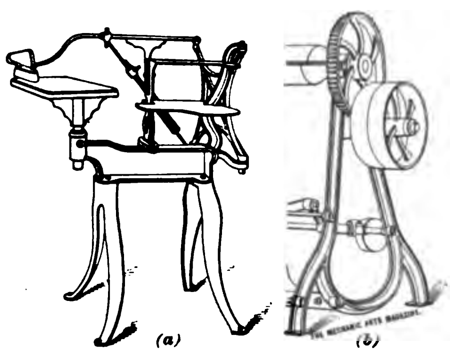


FIG. 1.

The reader must not confound notions with talent, ingenuity, or intuition. The former have nothing to do with these attributes; they are more of the nature of habits, and, like habits, may be good or bad ones. The good notions are acquired by training, preserved by constant checking, and refined by continually taking note of things. The bad ones are mostly inherited. They are with us to a greater extent than is generally realized, and in the art of machine designing are quite strikingly apparent more or less in all classes of machinery, and are no small impediment in the development of synthetic designing. Thus, it has taken many years to eliminate the resemblance to a stage coach from the railroad car, and it will take a long time to eradicate the horse from the horseless carriage, so that it may be less carriage than the automobile is as yet. We have but to look into the details of various kinds of machinery to find bad notions embodied everywhere, and it is as good as a year in college to be able to see them. Thus, wrong notions about the strength and stiffness of machine parts, frames, and other details are most conspicuous in certain classes of labor-saving machinery, agricultural machines, and all such contrivances that perform their functions merely by virtue of their ingenious mechanisms, and in which strength of material does not come into play much beyond the necessity of keeping the parts together. In these machines we still admire the art of the patternmaker of bygone days: beautifully curved legs [(*a*), Fig. 1], graceful contours of side frames [(*b*), Fig. 1], medieval S cranks, and ogee pulley arms. In most of these cases, the crookedness of the parts mentioned does no particular harm, but certainly no good, and a designer should not sin any more than any other mortal just because he is not likely to be found out; besides, in deviating from the right principles and getting in the habit of doing so he digs himself a pit into which he is sure to fall, sooner or later, as it will lead him to introduce the same artistic designing into machinery where it positively does harm.

One still, occasionally, comes across machine tools on which the greatest ingenuity has been displayed in the endeavor to produce a maximum degree of exactitude in the finished product, but without avail on account of wrong notions in shaping and proportioning the details. This is notably the case with the frames of such machine tools. It is impossible to calculate the amount of deflection of the same, the forces acting on them being comparatively small, indefinite in magnitude and direction, so that a right notion of the most suitable shape to insure stiffness is of the greatest importance. In the earlier days of machine tools,

the frames of lathes, drills, etc. showed decided architectural design; the necessity of greater stiffness was, however, very soon realized, and the frames began to be built

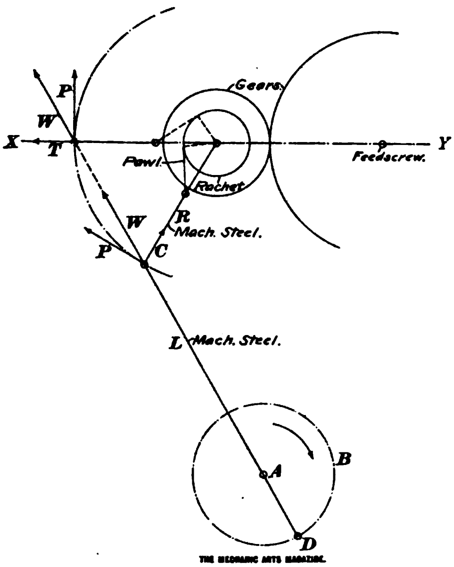


FIG. 2.

heavier, which only partly fulfilled the requirements, inasmuch as the end was gained by unnecessary expense for material. Today, the hollow or box frame, with its plain, shapely, outside appearance and proper distribution of material, is almost universely adopted as giving the most stiffness with the least amount of material. One hardly ever thinks of using any other but this system, nowadays, for such frames; it has become a well-founded, good, and firm notion with machine-tool designers.

As important as it is to acquire correct notions, it is equally so to get rid of bad ones. There seems to be a certain innate weakness with most geniuses in the mechanical line to make things as crooked as possible. For no apparent reason, levers are bent and rods given a kink, castings embellished with ribs where they should not be, etc. Fig. 1 affords a mild example of what we mean. If the would-be designer discovers any symptoms of such a weakness he had better combat it at the very beginning. As strong prophylactics, the following two prescriptions are recommended: (1) *Use straight or circular outlines whenever possible.* (2) *Make your details as symmetrical to the directions of the forces acting on them as the case will admit.* Consideration of the fact that irregular-shaped machine parts cause difficulties and consequent expense to the pattern shop, foundry, and machine shop alike, will amply demonstrate the correctness of the first rule. With regard to the second, examples will be given later on that will show its effectiveness.

As long as the work of the young designer is confined to alterations of existing designs he will naturally follow the originals with regard to shapes. When, however, something entirely new is to be made, he is required to use his own judgment. The information that reaches him from his superior, in most cases, consists of drawings and sketches showing a mere mess of center lines, paths, and positions, a few suggestions as to details, perhaps, notes containing fundamental data, and the gross dimensions calculated therefrom. From this information, which constitutes the *scheme* of the design, the practical working machine must be evolved; as it were, flesh must be built around the skeleton. This work is called *detailing*, and is the very soul and life of the designer's art. Its importance has been and still is, to a great extent, greatly underrated in our institutions of learning. It is, however, to be stated with a great deal of satisfaction that attention is being

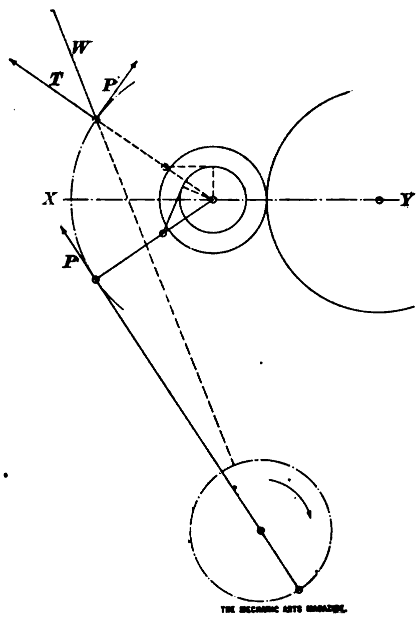
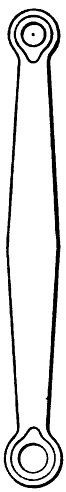


FIG. 3.

directed to it more and more, and that so-called courses on machine design will soon cease to be mere lessons in mechanical drawing, with a few typical machine

parts and empirical formulas to match, as examples. Nevertheless, skill in detailing will forever have to be acquired by practical work.

The mode of procedure in detailing is generally the following: The scheme is first carefully studied, and in doing so the detailist continually forms ideas as to the probable shape of the various parts, links, levers, bearings, etc. It is in this phase of the process that the "notions" play their important part. To a great extent the same process must naturally have been gone through by the head man in scheming, and many designers prefer to completely lay out the whole machine, especially if it be a complicated one, in which interference of parts may easily be encountered. In such a case, nothing remains for the detailist to do but to take every detail part from the *preliminary design*, as the scheme may then be properly called, test it as to its strength, give it the proper dimensions and fit it back again, the result of his labors being a set of pencil drawings, containing every piece in detail, as well as various views of the completed machine and parts of the mechanism, if necessary. These views will naturally be, unless some serious deviations have become necessary during the detailing process, revised editions of the original or preliminary design. With a good detailist for an assistant, the scheming designer can reduce his labors, and, consequently, expenses, to a minimum, going into detail only at such points where unusual difficulty arises, and, therefore, extraordinary methods must be resorted to. In such a case, then, the detailist must supply the rest, develop the other details in shape as well as proportions; in other words, he must complete the preliminary design first, from which the set of drawings, referred to above, are then made. As we have heretofore supposed the young designer to be an expert mechanical draftsman, there is no need of going into any deliberations about the mechanical execution of this work with regard to scales, selection of views, sections, etc., but we deem it necessary to draw attention to the following: The set of pencil drawings mentioned, being the result of considerable labor and thought, represent an investment, the value of which should be preserved. This is not always done. Whereas, in a great many drafting rooms, designers are required to make their own tracings, they are apt to be slouchy in the execution of the penciled sheets, omitting fillet and finishing marks, dimension figures, and other notes necessary for the shop, leaving all this to be filled in when the tracing is made, the latter being considered the final document of value. This is not the case, however; it is simply a copy on transparent material for the purpose of photographic reproduction, and should it become lost, or the design require alteration, it will be necessary to go back to the original, which, when executed in a careless way, will make the preparation of a new tracing expensive, be it either the same or an altered design, since it will require constant reference to the old tracing, or a blueprint copy of it, and, in case neither is at hand, a great deal of work already done must be gone over again, even if the same man that made the original pencil drawing is to make the tracing. It is clearly seen that matters are worse when the tracing is to be done by another man, to say nothing of trying to save money by having such work given over to tracer boys, which may be confidently done with considerable economy in case pencil drawings are neatly and in every respect completely finished. By this we do not mean to recommend "inking in" original drawings, nor the careful erasure of all auxiliary lines due to graphical solutions of stress problems, construction of angles, finding of centers, etc.; on the contrary, the original should remain in pencil, so that if at any future time it should come about that certain portions of the design are definitely abandoned, the lines representing them may be easily erased, and auxiliary lines, as well as any notes giving reasons why such and such a part was made in the manner shown, should be carefully preserved; they will come handy when any alterations are called for. It is true that these lines make it more difficult for a tracer to do his work, and it is the designer's duty,



THE MECHANIC ARTS MAGAZINE.
FIG. 4.

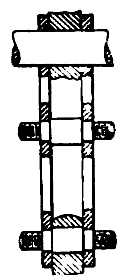


FIG. 5.

in justice to the boy, to distinguish the lines to be traced from those to be left out. This can easily be done by going over the former as a sort of finishing touch with a hard pencil, giving it more than ordinary pressure; the lines thus treated will show much more plainly through the cloth than the naturally faint auxiliary ones.

After this digression, let us take up an example in detailing to show the workings of the two rules given above, together with a number of other things. Let Fig. 2 be a portion of a "scheme" handed down to the detailist. It shows a very simple feed-motion. On the shaft *A*, which moves at a uniform speed, is a crank-disk *B* with pin *D*; a rod *L* connects this disk with a lever *R*, having a pawl attached to it that meshes with a ratchet wheel. The latter sits on a shaft, which also carries a gear, transmitting motion to another gear attached to a feed-screw. The first thing to do with this is to carefully study it, and in doing so we will find that there is more to study about it than might appear on first sight. Inasmuch as the rule given above bids us consider the forces acting on the various parts, we shall follow them up. A certain force will be necessary to turn the feed-screw, and, supposing this to be the same during the whole duration of the feed, there must be a uniform push *P* at the end of the lever *R*, and at right angles to it; this push is supplied from the rod *L*, which, in order to do so, must also exert a push or pull on the direction of the length of the lever *R*. Laying these forces out, according to the parallelogram of forces, as has been done in Fig. 2, the fact is revealed that at the beginning of the stroke the radial force *C* is in the direction of the shaft; that is, it subjects each section of lever *R* to compressive stress; at the end of the stroke the radial force *T* is in the opposite direction, subjecting the lever to tension, but in magnitude equal to *C*. The bending effect of the force *P* is equal in both cases, and so is the push *W* on the rod *L*. This state of affairs is evidently not accidental, but intentional, on the part of the one that schemed the mechanism, and he expects the detailist to see it. By this arrangement, the forces acting on *L* and *R* are as uniform throughout the stroke as the case will allow, the maximum stress being the same at the beginning as at the end, and, in the case of the lever *R*, a compressive stress at the beginning and a tensile stress at the end, allowing the use of iron or steel, as specified, in making the section of the lever perfectly symmetrical. Let us see what the outcome would be if the designer, instead of planning in symmetry with the acting forces, had followed his sense of beauty and made the lever swing an equal distance above and below the horizontal line *X Y*. Following up the forces, as done in Fig. 3, one will see that, at the end of the stroke, the force *W* necessary to be supplied by the rod in order to have the same tangential force, *P* must be considerably greater, and the pull *T*, on the lever, will also be much greater, necessitating a larger section of the same. At the beginning of the stroke the stresses are much smaller; in our particular case, *T* disappears and *W* becomes *P*, so that for all other positions, except the stroke end, the increased section is sheer waste of material. Now, this certainly does not amount to much in dollars and cents when the forces are small, as in the feed-mechanism of a machine tool, and the various parts, such as lever *R* and rod *L*, are probably more than three or four times stronger than necessary; but it may amount to a great deal when a similar arrangement is used to transmit larger forces. On the other hand, there are considerations equally as important as economy of material.

In the first place, every stress is accompanied by a corresponding deflection of the machine parts stressed, and it is easily imagined that, when a string of links, such as cranks, rods, levers, etc., are so connected that the various deflections add together, the total deflection may be considerable, and then we wonder that the machine quivers and shakes. In the second place, if the acting forces are not uniform, or nearly so, the pressure on the wearing surfaces is not constant, but periodical, each period of pressure being followed by a release. This is described in some books on machine design as an advantage, on account of the pumping action thus established helping to produce a uniform distribution of lubricants. This may be true under certain circumstances, but, as a rule, especially in complicated mechanisms, the thumping action that establishes itself with the beginning of wear is far more of a nuisance than the absence of the pumping action.

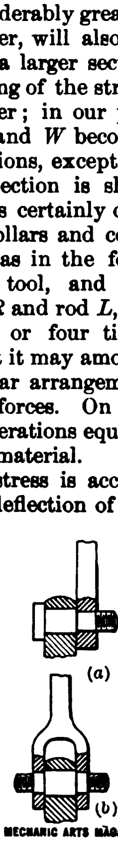


FIG. 6.

Having studied the scheme and appreciated its hidden virtues, if there be any,

the detailist must give the parts their suitable shapes and dimensions. Starting with the rod L, the same will have to be treated as a column rounded at both ends, and, for greater economy and stiffness, be made thickest at the middle, slightly tapering down toward the eyes, and of circular cross-section throughout, as sketched in Fig. 4. It will be noted that the lower eye, the one at the crank-disk, is larger than the one at the other end. The reason for this is that the crankpin, being necessarily supported on one end only, must be stout enough to preclude any possibility of deflection, while, as we will presently see, the pin or bolt at the other end can be supported on both ends, and therefore be made much smaller. We come now to the lever R. As it is to be of machine steel, according to directions, we conclude to make it of rectangular cross-section. The bending action of P being the greater, the farther the section is away from the point of application; we could make the lever increase in height toward the ratchet wheel, and would do so if economy in material were a matter of consideration against the cost of making the lever tapering. We will assume that this is not the case, and thus make it a sufficiently great and uniform section throughout. Moreover, in order to dispose of the material symmetrically with regard to the acting forces, we can make it of two pieces, one on each side of the rod L; the whole lever then consists simply of two flat bars with three holes, rod, pawl, and ratchet wheel between them, as shown in Fig. 5. The two halves of the lever may, finally, be securely united by making the pins as indicated in the figure, which has the effect of clamping all parts together, and making the greater length of the pins the journals for the moving parts. In conclusion, let us see what would have been the effect if we had made the lever R differently, that is to say, out of one piece. Then, if we wish to retain the simple flat bar, we must place it sidewise to the rod, pawl, and ratchet, as in (a), Fig. 6, introducing bending stress in the rod, and torsional stress in the lever, with consequent increased springiness of these parts. If, on the other hand, we wish to retain symmetry in the disposition, we must resort to costly forgings, as in (b), Fig. 6.

THE VELOCITY POLYGON.

George A. Goodenough.

THE OBJECTS OF STUDYING THE MOTIONS OF A MACHINE—A SIMPLE METHOD OF PICTURING VELOCITIES—THE MOTION OF THE JOY VALVE GEAR.

IN STUDYING the motions of the various parts of a machine, or of a simple mechanism, the object in view is one of three things: (1) the positions of various points or links relative to each other; (2) the velocities of the various parts, or certain points of these parts; (3) the accelerations of these parts. Frequently only the first of these objects demands attention; thus, in designing an indicator reducing motion, we aim to make the pin, to which the indicator card is attached, occupy a certain position when the crosshead is in a similar position. The relative positions of these parts is the object of our investigation, and we care nothing for the velocity or acceleration of the crosshead or any other part. In other cases we seek to determine the acceleration of a point in the mechanism. For example, in the design of high-speed engines it is considered quite necessary to determine the accelerations of the points of the connecting-rod, so that the inertia forces acting on the rod and tending to bend it may thereby be determined. Again, we may wish to determine the relative angular velocities of different links, or the relative linear velocities of points on the same or on different links. Instances of this are seen in complicated gear-trains.

In HOME STUDY MAGAZINE, July, 1898, article entitled "Plane Motion," was explained a method for finding relative linear velocities by means of the instantaneous centers of the mechanism. This method is perfectly general and may be applied to any case in which these centers can be found. There is, however, another method, which, while not of so general application as the other, is much more easily used in the cases to which it is suited. This second method we will now proceed to explain.

As the simplest possible case, we take first the 4-link mechanism, Fig. 1, consisting of

the fixed link, or bed, a, the cranks b and d, and the coupler c. The joint between the two links b and c we denote by $(b\,c)$, and similarly for the other joints. Suppose we know the velocity of the point $(b\,c)$ for the given position of the mechanism, and wish

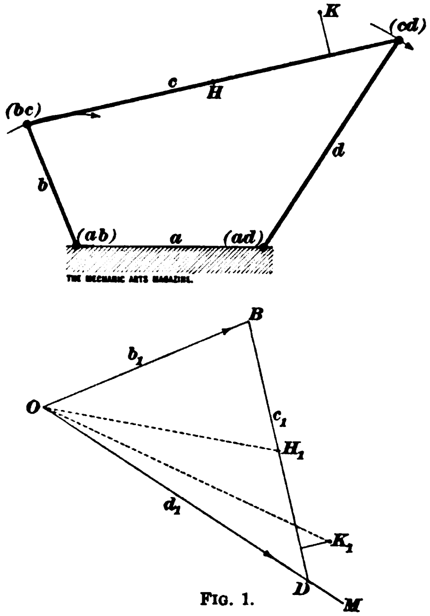


FIG. 1.

to find the velocities of any or all points of the various links. We choose any point O as a pole, and draw a line $O\,B$ perpendicular to the link b, making the length $O\,B$ to some scale equal to the known velocity of the point $(b\,c)$. Since the link b is rotating about the point $(a\,b)$ as a center, it is evident that the direction of the velocity of the point $(b\,c)$ is perpendicular to the line joining $(b\,c)$ to the center of rotation $(a\,b)$, that is, to the link b; hence, the line $O\,B$ represents the velocity of $(b\,c)$ both in magnitude and direction. A similar process of reasoning shows that the velocity of the point $(c\,d)$ must have a direction perpendicular to the link d, since this link is rotating about the point $(a\,d)$ as a center. Through the pole O, therefore, we draw an indefinite line $O\,M$ in the direction of the velocity of $(c\,d)$, that is, perpendicular to the link d. Now, through the known point B we draw a line perpendicular to the coupler c, cutting the line $O\,M$ in the point D. We have thus obtained a triangle $O\,B\,D$, the three sides of which are perpendicular, respectively, to the three moving links b, c, and d of the mechanism. The side $O\,B$, perpendicular to b, we denote by b_1; that perpendicular to c by c_1; and so on. In particular, the point D, the intersection of c_1 and d_1, corresponds to $(c\,d)$, the joint uniting the links c and d.

This triangle $O\,B\,D$ is used as follows: The line $O\,B$ we assumed to represent the direction and magnitude of the velocity of $(b\,c)$; then, the line $O\,D$ represents to the same scale the velocity of the point $(c\,d)$. Suppose we wish to find the velocity of some point on the link c, say the middle point H. In the triangle $O\,B\,D$, the side $B\,D$, or c_1, represents the coupler c; hence, we locate the point H_1 at the middle point of c_1 and draw a ray $O\,H_1$; then, $O\,H_1$ gives the direction of the velocity of H and also its magnitude to the same scale that $O\,B$ gives the magnitude of the velocity of $(b\,c)$. Suppose we wish to find the velocity of a point K, not in the line $(b\,c)$–$(c\,d)$, but attached to the coupler c. We have simply to locate the point K_1 in the position relative to c_1 that K has relative to c; then the ray $O\,K_1$ gives the direction and magnitude of the velocity of the point K.

The mechanism just considered has only turning joints. If, in addition to such joints, it has parts that slide to and fro, the construction is somewhat modified; but if the part slides in guides attached to the fixed link, or bed, of the machinery, the construction is not rendered more difficult. As an example, let us take the familiar 4-link steam-engine mechanism shown in Fig. 2. The crank b turns about the joint $(a\,b)$, the block d—the crosshead in the actual engine—slides to and fro, and the coupler or con-

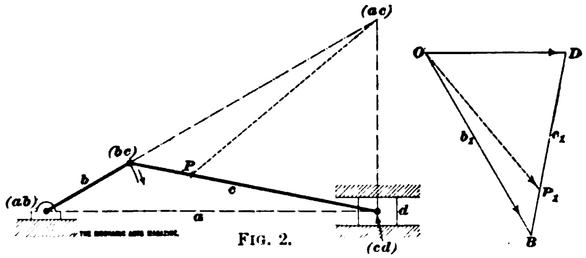


FIG. 2.

necting-rod c has a peculiar oscillating motion. We will assume that the velocity of the crankpin $(b\,c)$ is known; choosing any point O as a pole, we draw a line $O\,B$ perpendicular to the crank b; the length we make equal to the magnitude of the velocity of $(b\,c)$, to some assumed scale. The block d

is constrained to move in the direction of the line (ab)-(cd); hence, we draw from O the line OD in the direction of the motion of D, that is, parallel to the line (ab)-(cd). Now, through the point B we draw a line perpendicular to the link c and intersecting the line just drawn in D; this last line we denote by c_1, and the line first drawn by b_1.

The triangle ODB in Fig. 2, like the triangle of Fig. 1, gives a means of determining the velocities of all points of any moving link of the mechanism. The line OD represents the velocity of the point (cd) and, in fact, of all points of the slide, to the same scale that OB represents the velocity of (bc). The line c_1 represents the rod c, and the velocity of any point P of the rod is found by locating the corresponding point P_1 on the line c_1. Joining this point to the pole O, the ray OP_1 represents the velocity of P, both in magnitude and direction. The only difference between this case and the first is that the block d is represented by a single point D instead of by a line d_1. That this must be the case is apparent. The block has a motion of translation, and all points of it have the same velocity; this common velocity is represented by the distance OD, and therefore the point D corresponds to all points of the block.

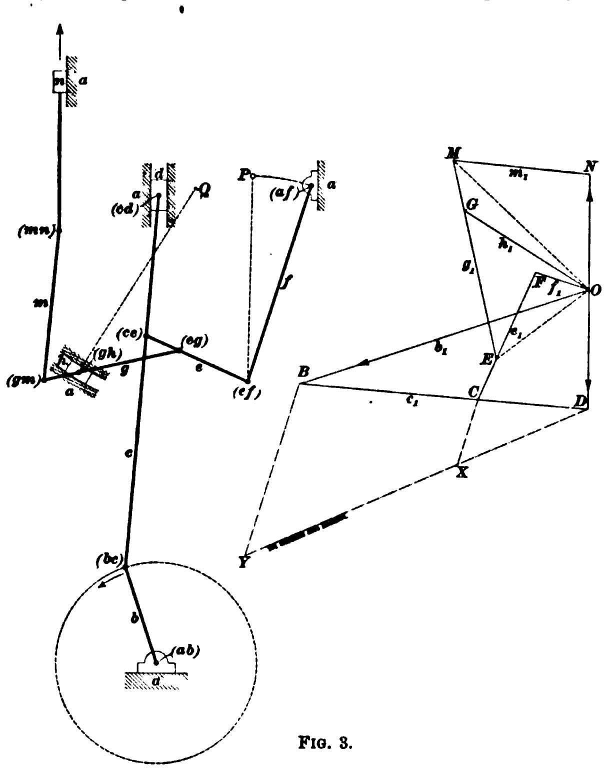


FIG. 3.

We will now study a more elaborate mechanism, and choose for the purpose the Joy valve gear, Fig. 3. This mechanism may be described as follows: The four links a, b, c, d form the ordinary steam-engine mechanism, b being the crank and d the crosshead. To some point (ce) of the connecting-rod c is jointed a link e, the other end of which is connected to the bed or fixed link a by a rod f. At a suitable point (eg) of the link e is jointed a link g, which carries a block h; this block is constrained by fixed guides to move in a circular path, the center of which is at the point Q. The end (gm) of the link g drives the valve n through the rod m. The velocity of the crankpin (bc) is known or assumed, and the problem is to find the velocity of the valve n or the velocity of any other point of the mechanism.

For the position of the mechanism shown in the figure, the velocity polygon is constructed as follows: Through the chosen pole O, the line b_1 is drawn perpendicular to the link b, and the distance OB is laid off to represent to some scale the known velocity of the point (bc). Through the point B, the line c_1 is drawn perpendicular to the rod c, and through O a line is drawn in the direction of the motion of the block d; these lines intersect in the point D. Evidently, the point D represents the slide d, and the line BD, the link c. To find the velocity of the point (ce) of the link c, the point C is so located on c_1 that it divides BD in the same ratio that the point (ce) divides the rod c. A common graphical construction for locating C is shown in the figure. Through D is drawn a line at random and on it is laid off $DX = (cd)$-(ce), and $DY = (cd)$-(bc). Y is joined to B and a line parallel to YB through X cuts BD in the required point C. Through C a line e_1 is drawn perpendicular to the link e, and through O a line f_1 is drawn perpendicular to the link f; these lines intersect at F and the lines CF and OF represent, respectively,

the links e and f of the mechanism. The point E is now located so that it divides the line CF in the same ratio that the point (eg) does the link e. Through E a line is drawn perpendicular to the link g, and through O a second line is drawn in the direction of motion of the block h, that is, perpendicular to the line (gh) Q. These lines intersect in the point G, which corresponds to the point (gh) of the mechanism. The line EG is prolonged, and the point M is so located on the prolongation that it has the same position relative to G and E that the joint (gm) of the mechanism has to the points (gh) and (eg). Then the point M corresponds to the point (gm) of the mechanism. Finally, through O, a line is drawn in the direction of the motion of the valve n, and a second line m_1 is drawn through the point M perpendicular to the link m. The single point N represents the valve n, which has a motion of translation, and the line m_1 represents the link m.

It should be noted that the lines corresponding to links attached to the fixed link or engine bed a are drawn from the pole O; the other lines—in this case c_1, e_1, g_1, and m_1—do not pass through the pole.

The figure we have just drawn we call the velocity polygon for the given position of the mechanism. It gives at once the velocity of any point of the mechanism. Thus, ON represents the velocity of the valve, OG the velocity of the point (gh), OE the velocity of the point (eg), and so on. The polygon is a sort of picture that tells at a glance how fast and in what direction any point of the mechanism is moving.

The velocity polygon is useful in tracing the influence of a change in the position or proportions of a link. Suppose, for example, that the end (af) of the link f is located in a new position P. What effect will this have on the velocity of the valve n? Referring to the polygon, it is clear that the perpendicular f_1 to the link f will, in its new position, be more nearly vertical, and, as a consequence, e_1 will be shortened. The joint E will be nearer C than before, and the line g_1 will be longer and farther from the pole O. As a result, the point M will be higher than in the position now shown, and ON will be lengthened. This shows that the change will increase the velocity of the valve. It will prove an interesting exercise for the reader to trace out the result of other changes. For example, what will be the effect of changing the position of the point Q so that Q (gh) is about vertical?

The method of finding velocities by means of the velocity polygon is applicable to the many mechanisms that are composed of links united by turning or sliding pairs, and it is precisely in this class of mechanism that it becomes difficult and tedious to locate the many instantaneous centers required by the general method. When, however, the mechanism contains gear-trains or cam-trains, it is usually difficult to construct the velocity polygon, and the general method is to be preferred.

SOLDERING.

THE chief difficulty experienced by a beginner, in attempting to solder two pieces of metal together, is to secure an even flow of the solder between the pieces, which is necessary to make a strong union. Either the surfaces to be joined have not been thoroughly cleaned, or the soldering iron is too hot, or not sufficiently tinned; and, as a result, the solder runs off in little globules of melted metal, or masses unevenly at one place and not at another, instead of spreading uniformly in a thin film over the joint, as it should. The consequence is that we have, when the work is done, a weak joint, and one presenting a decidedly botched, untidy appearance. In fact, we have proved ourselves poor workmen.

Many of these difficulties may often be avoided, in uniting small pieces of tin or brass, and a neat and strong union be obtained, without the use of a regular soldering iron, in the following manner: Scrape the surfaces to be joined with a small knife blade till bright and rough, and avoid touching them thereafter with the fingers. Sprinkle over them a little finely powdered resin, which may be pressed with the blade of a knife, to cause it to adhere to the surfaces. Now lay the surfaces together, with three or four thicknesses of bright tin-foil between them, and hold or secure them firmly in position, while a red-hot poker or other iron is pressed strongly against the upper surface, over the joint. The heat must be ample to heat the metal and melt the tin in the joint, after which the iron is quickly removed, but the joint must not be disturbed in the slightest degree till cold.

HAULING CAPACITY OF LOCOMOTIVES.

H. Rolfe.

CYLINDER AND DRAWBAR HEIGHTS—CROSSHEAD THRUST AND RAIL PRESSURE—CENTRIFUGAL PULL OF "EXCESS BALANCE"—EFFECT THEREOF ON ADHESIVE FORCE OF DRIVERS.

A QUESTION that has doubtless occurred to the mind of many a locomotive man is this: "Will an engine pull more than she'll push (backing up)?" We can include this in the more general question of whether an engine will pull more when running stack first than when running tender first.

Such a question belongs, of course, less to tender engines than to tank engines and others engaged in local and suburban traffic that as frequently run one way as the other. These latter form a very numerous class in some European countries; by far the largest portion of this class as used in Great Britain consisting of passenger engines employed in suburban traffic, having front and main drivers and a four-wheeled truck behind. Now, so far from its being undesirable to run these engines backward, we may state that the Board of Trade condemns their being run the *other* way (i. e., stack first), the government officials properly arguing that the truck ought to lead. Coming back to the main point, however: will an engine pull more in fore gear than in back gear?

The first point bearing on the matter that occurs to us is naturally that of drawbar position. This line of argument may be presented as follows: There are two forces at work, that of the steam tending to force the engine forward, and the resistance of the train pulling the engine backward. During the outward stroke, in fore gear, the propelling power is the steam acting on the front cylinder head, while during the return stroke it is the pressure exerted on the front pedestals; vice versa for back gear. For our present purpose, and for the sake of simplicity, we will take Fig. 1 as representing the general case of a locomotive, the action of the steam being replaced by an external force; this will suffice for illustrating the action we are now concerned with. The unpretentious figure represents a small crude locomotive, pulled by a man at P and held back by the weight W. If the ropes r and r' are exactly in line with each other, horizontally, there will be no tilting action of the engine. Both wheels will rest fair on the rail, their pressures thereon remaining constant, the springs s, s being unaffected. If, however, r and r' are as shown in Fig. 2, the two efforts, P and W, tend to slew the engine in a vertical plane around its center of gravity until r and r' come into line with each other (P and W forming a couple whose arm is l and moment Pl or Wl).

Now, the above is just what happens in the case of an actual locomotive. The "exigencies of design" render unavoidable a distance of several inches between the two lines of force r and r', that is, a difference l in the heights of the drawbar and cylinder, l being anything up to 9 inches or more,

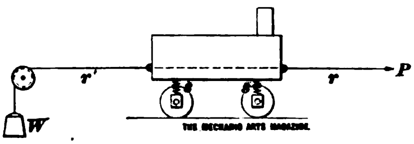


FIG. 1.

depending chiefly on the size of drivers. Now, whether the actual impulse sending the engine along be applied at the cylinder head or at the pedestals (according to the gear and the direction of stroke), the tendency for the engine to tilt remains practically the same, assuming the cylinder to be horizontally in line with the main axle, which, in fact, it very nearly is when the brasses are worn and the springs settled down. This lift at the front end is shown exaggerated in Fig. 3. The wheels, of course, do not leave the rail, but the engine rises on her springs; the consequence is that some of the weight is taken off the front wheels and imposed on the rear ones. If the engine is an eight-wheeler, it ought not to make much difference in driver adhesion, because it is the truck that suffers chiefly, the weight being taken off that and thrown on the drivers; any loss of weight on the main drivers would be an increase on the rear drivers. It looks, at first sight, as though the weight lifted off the front end were carried by the drawbar, so to speak, but, as a matter of fact, the load on the rail remains the same. If the block shown in Fig. 4 were scotched at a so as not to slide,

and were then raised up by a pull at P, the force R on the rail at a would, it is true, be greater than W, being, in fact, the resultant of W and P, but its vertical component r (the downward pressure on the rail) would still be only equal to W, the horizontal component $r' = P$ being expended in setting up

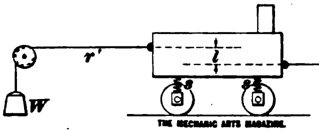


FIG. 2.

a horizontal thrust in the rail, tending to shove it backward in the direction of the arrow.

Where the engine is four-coupled in front (which, as already remarked, is very frequently the case in some countries), it seems as though the engine would suffer on the above account, for when running stack first some of the weight is lifted off the front end. The net effect, however, is chiefly a transference of weight from the front drivers to the main ones, and, so far, there is an advantage as providing a margin against incipient slip, the more especially as the side rods are nearly always bushed, and therefore may be expected, in average condition, to have plenty of play. When running rear end first, however, more weight is thrown on the drivers as a whole.

However, this tilting action is, in general, perhaps less pronounced "over yonder," as the average size of drivers is larger than with us, and l, therefore, less. The effect is most noticeable here on mogul engines, when pulling hard, owing to their small wheels and light weight on trucks; the fact of the cylinders being outside (and, therefore, more widely spread) giving the steam

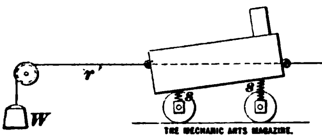


FIG. 3.

more leverage in producing "elbowing" motion, this being accentuated by the lessening of weight on the pony truck.

We shall now deal with another phase of the question, and one that will, perhaps, be new to a good many of our readers.

It is known, perhaps, to every locomotive man that the crosshead presses on the top guide in fore gear and on the bottom guide in back gear. This pressure varies from nothing at the beginning and end of stroke to a maximum at the middle, so far, at least, as the relative lengths of main rod and crank are concerned, which relation, by the way (the steam pressure being assumed to be the same), is the only thing that influences the crosshead pressure.

Now, in Fig. 5 we have steam acting on the piston as shown by the arrow F, and the consequent motion of the piston, etc. is opposed by the resistance of the crankpin P to rotation, which resistance sets up a thrust in the piston rod and main rod. Now, one feels intuitively, without any analysis, that the tendency is for the combination of parts $A\ B\ C$ to buckle up, and it would do so, in fact, were not the crosshead held down by the top guide. On the return stroke (see dotted lines) the tendency is for $A\,B\,C'$ to straighten out, because, now, the piston rod A and the main rod C' are pulling against each other. If, now, for a moment, we

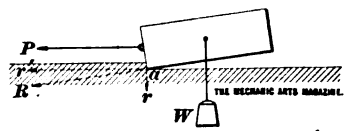


FIG. 4.

imagine the crankpin and hub to be connected to the frames, we shall see that the stresses are self-contained, and thus the top guide is, through the medium of the frames, pulled down as much as it is pushed up. But, as a matter of fact, the crankpin is not attached to the engine proper, but to an altogether external body, namely, the driving wheel. Therefore, when the reaction due to the thrust on the pin comes on the top guide, the front end of the engine is lifted slightly on the springs, thus easing the weight off the leading wheels. Where has this lost weight gone to? The answer is: on to the drivers. The total weight on all the wheels remains, of course, the same, but part of it has, by the action of the main rod, been transferred from the front wheels to the drivers. We can look at this in another way: we may regard the total weight on the rail at x as being $W + T$, the dead load being increased by the amount of the steam thrust, or at least by its vertical component, which is T. The reactionary thrust T' on the top guide leaves us with that much less weight on the front wheels, the total of all the wheel loads thus remaining constant. Now, when the engine is running backward, the

tendency on the out stroke is for $A\ B\ C'$ to buckle downward, and on the return stroke for $A\ B\ C$ to straighten out (see Fig. 6). The consequent downward pressure of the cross-head is, in each case, resisted by the lower guide.* There is thus an extra load imposed on the front wheels. As the total weight on all the wheels remains the same, whatever the steam stresses (but neglecting centrifugal stresses), the above weight must have been

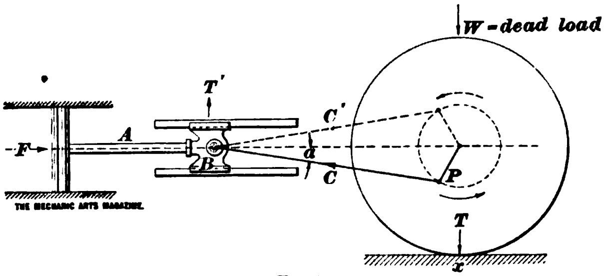


FIG. 5.

transferred from some of the other wheels—from the drivers, in fact, in this case. Thus, when running backward, the weight on the drivers is continually being intermittently diminished. The actual decrease of pressure T on the rail depends on two things—the relative length of main rod and crank, and the steam pressure. Let N stand for the number of times the main rod contains the crank; that is, if the rod is 8 feet long and the stroke 2 feet, N is equal to 8. For any given crank position, the greater the angle a between main rod and cylinder axis, the greater the thrust on the guides; and the magnitude of this angle depends on the value of N, varying universally thereas. For a given value of N the thrust is greatest when the crank is on the quarter, and for a given value of angle a the thrust varies with the steam pressure. Now, if the initial pressure were to be maintained up to, or beyond, half stroke, the maximum thrust would occur at that point (of course, the initial pressure never *is* maintained as far as this, however late the cut-off, as any card will show). With early cut-offs the pressure may drop so much before half-stroke is reached that the maximum thrust may occur at, say, three-eighths of the stroke, this drop depending on the speed of revolution, length of valve travel, and type of valve, as well as on the percentage of cut-off. Now, not only does the thrust (or pull) T attain its greatest value when the crank is on the quarter, except in very early cut-offs, but there has also to be considered the centrifugal pull of the "excess balance," that is, of that portion of the counterweight put in to balance a part of the reciprocating weight. This pull acts to decrease the rail pressure only, of course, when the crank is on the *bottom* quarter (we are only considering the quarters now). If we look into the matter we shall see that, as regards the joint effect of the centrifugal pull and the steam thrust, we are worse off in back than in fore gear. Letting P denote the pull of the excess balance (this "pull" being a thrust on the rail when the crank is on the top quarter) and T the vertical thrust of the main rod on the rail, we shall have on the top quarter a force $T+P$ holding the wheel down, in fore gear, and $T-P$ lifting the wheel up, in back gear. When on the bottom quarter we shall have in fore gear $T-P$ holding the wheel down and, in back gear, $T+P$ lifting it up (see Fig. 7). To arrive at the actual rail pressure in each case, we should, of course, have to add the original dead load. It may be remarked that, as a matter of fact, these forces do not increase and decrease together. One is most inoperative when the other is least so, and the converse; thus, the cross-head thrust is greatest at low speeds and least

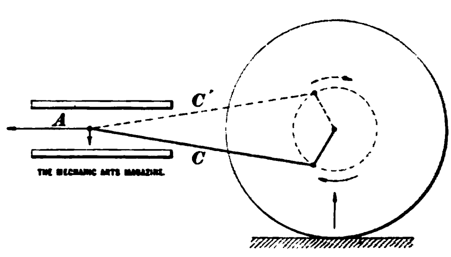


FIG. 6.

at high speeds, whereas the pull of counterweight is exactly the reverse of this, varying directly as the speed. Hence, "$T-P$ up" is actually an upward lift from the rail if $T-P$ is positive; if it is negative, the "lift" becomes a push down on the rail.

As regards what has been said of the steam thrust, we can readily convince ourselves that they take effect as described, by

* Any one that cannot see that this is so, can prove it, experimentally, by nailing a thin piece of leather over the ends of two pieces of wood, butted together end to end, and then alternately pulling and pushing at them. See, also, HOME STUDY FOR MACHINISTS, STEAM ENGINEERS, ETC., July, 1898.

considering the following suppositions: (1) If we were to stand on the ground underneath the guides and lift upward against the weight of the engine, we should take a certain amount of the weight on our shoulders, and therefore off the rail. (2) If we were to stand on the buffer beam and lift up under the smokebox, we should not affect the weight on the rail at all. (3) Again, if we could diminish in size, like Alice in Wonderland, so as to get in between the guides, and, standing on the lower one, press upward against the top one with our shoulders, the weight on the rail would remain the same. (4) If, however, while in between the guides, we were to press down vertically on the ground with a stick, we should take some of the weight off the rail, reproducing the conditions supposed in (1). Now, if we go a step further, and hold the stick slanting, so as to touch the ground a few feet away from the guides, and push down on it as before, part of the push takes effect on the guides, tending to displace them fore and aft—this horizontal component of the push corresponding to the frictional effort of the crosshead; the other, and vertical, part of the push tends to lift the top guide upward, carrying the engine with it. Now, the push of the piston rod produces a downward thrust in the main rod that may be substituted for the above, the crosshead representing the body and the main rod the stick. The effect is precisely the same—the top guide is lifted and the engine bears correspondingly lighter on the front wheels. We will regard it as established, then, that during a greater part of the time the rail pressure of the drivers is less in back gear than in fore gear. We can now consider the main issue.

What determines the hauling power of a locomotive? It is dependent on two things: (1) the tractive power, and (2) the adhesion. Since the first of these is of no earthly use without the second, we may reasonably assert that the second determines the hauling power, and that if this is diminished the hauling power will be also. The actual extent of this diminution depends on many things, as already pointed out; it may be anything up to, say, 3,500 pounds in an ordinary eight-wheeler—and the difference of adhesive force in the two gears *is twice this*, for it is put on in the one case and taken off in the other. It seems not unreasonable, then, to assert that an engine will pull more going stack first than when running tender first.

This change of rail pressure is rapid and intermittent, it is true, but without doubt there is a corresponding amount of slip, at least when pulling hard. In other words, an engine that can only just handle a certain train in fore gear would certainly lose time with it in back gear.

This argument does not apply when all the wheels are coupled as in British freight engines, which are all carried on six drivers and have no truck. Even there, however, this constantly-recurring variation of pressure will make itself felt, for although any transfer of weight from the main to the front drivers does not affect the gross driving

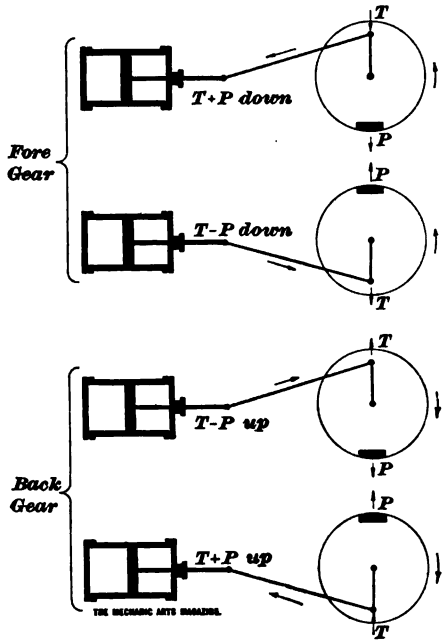


FIG. 7.

weight, yet it may, and undoubtedly does, cause incipient slip of the main drivers. This kind of slip is always present, more or less, until the wheel gets the benefit of its fellow, which is not until the slack in the side-rod brasses is taken up, and by that time the wheel has got a certain amount of "way" on it and so is not immediately checked by the coupled wheel in question. So it is as well to give the main drivers 1½ or 2 tons more weight than the front pair, the rear pair having a little less still than the latter. This, in fact, is generally done, each spring being independent of the others.

It is, perhaps, more a matter of interest than of utility to look into this question further. On investigation, it will be seen that the crosshead thrust in fore gear really tends to

relieve the main drivers as well as the front wheels, the respective proportions depending on the position of the crosshead relative to the wheels in question. Thus, the net increase of weight on rail under main driver is the vertical component of main-rod thrust less the proportion of total relieved weight (due to crosshead thrust), which is taken off the main driver. Also, in inside-connected engines, the thrust relieves both sides of the engine; in outside-connected it relieves only the wheels on its own side, throwing extra weight on those on the other side. Similar remarks apply to back gear, except that weight is relieved where before imposed, and vice versa. However, it has been deemed sufficient to advert merely to the main facts; for, although the question may be of interest per se, yet it in no way influences the designer; it goes a long way, though, toward explaining uneven wear of tires.

A GREAT DISCOVERY.

(Continued from the September, 1899, Number.)

George McC. Robson, M. A.

DISCOVERIES IN MATHEMATICS AND IN OPTICS—MEANING OF KEPLER'S LAWS—LAW OF THE INVERSE SQUARE—THE MOON A FALLING BODY.

> "I brought to earth a spark of heavenly fire,
> Concealed at first, and small, but spreading soon
> Among the sons of men, and burning on,
> Teacher of art and use, and fount of power."

On retiring from Cambridge in the plague year (1665–1666), Newton devoted himself earnestly to the investigation of the profound subjects to which he had been introduced during his residence in the university. He was principally occupied with the science of optics, algebra, and the method of fluxions. In the beginning of the year 1665 he discovered the method of approximating series and the rule for expressing any power of a binomial in such a series. In May, of the same year, he discovered the method of tangents of Gregory and Shisius; in November he had invented the direct method of fluxions (differential calculus); in January, 1666, he had discovered the theory of colors; and in May, 1666, he began to develop the inverse method of fluxions (integral calculus). It is marvelous that so many great discoveries, involving so much labor and deep thought, should have been made within the space of two years by a young man not yet twenty-four years old; yet it seems to be the rule, rather than the exception, that great men accomplish their best work while they are still young, and Newton himself, in his later years, said that at this period he was in the prime of his age for invention, and gave more attention to mathematics and philosophy than at any subsequent time.

However deeply Newton was immersed in his mathematical and optical researches, he could not avoid giving some thought to the question of gravitation and the explanation of Kepler's laws, which was one of the great problems of the day. Kepler himself had suggested that his laws might be explained on the hypothesis that the force of gravity varies inversely as the distance, and Bouilland had proposed the substitution of the inverse square of the distance. Newton was acquainted with these and many other speculations on the same subject, including those of Descartes; and he knew that the fundamental error in all these speculations lay in the supposition that some force is necessary to keep a body in motion. Newton appreciated the importance of Galileo's laws of motion, and had fully grasped their meaning; he knew that force is necessary to change a body's motion, but a moving body will move forever, uniformly in a straight line, unless it is acted on by some force or forces. So clearly did Newton understand Galileo's laws, and so important was the use he made of them, that these laws are referred to in all English books as "Newton's laws of motion," and are quoted in the form in which he expressed them.

The law of centrifugal force was another important principle essential to the discovery of the law of gravitation, that Newton had discovered for himself at this time; though this law was first published seven years later, by Huygens. In the last chapter

of his book, "Horologium Oscillatorium," Huygens shows that, when a body moves in a circle with uniform velocity, the centrifugal force varies directly as the square of the velocity, and inversely as the radius of the circle. Newton assigns to Huygens the priority in making this very important discovery, though he discovered it independently before its publication by Huygens. The book of Huygens, to which we have referred, is a very important contribution to science; it contains his investigations relating to pendulum clocks and other matters of importance in theoretical mechanics, as well as some very beautiful geometrical theorems.

We shall now consider how Newton applied the three laws of motion and the law of centrifugal force to the consideration of Kepler's laws. Kepler's first law asserts that the path of a planet is an ellipse, which is not a straight line; hence, from the first law of motion, it is evident that the planet must be acted on by some force. Kepler's second law asserts that the line joining the planet to the sun sweeps over equal areas in any two equal intervals of time. From this law, Newton showed that the force acting on the planet must be directed toward the sun; the proof of this theorem is contained in the second and the third proposition of Newton's Principia. In the first proposition of the Principia, Newton proves that if a body describes a path under the action of a force directed to a fixed point, then the areas described by the line joining the body to the fixed point are in one plane and are proportional to the times of describing them; in other words, the first proposition of Newton's Principia shows that if the force acting on a planet is directed to the sun, Kepler's second law must be true. In the second and the third proposition he proceeds to show that if Kepler's second law is true, the force acting on the planet must be directed to the sun. Newton's demonstration of these principles is of the most simple and elementary character, and any explanation or amplification of his proof can serve only to throw obscurity on what he has rendered abundantly clear.

The equable description of areas under the action of a central force can be illustrated by a very simple experiment. If a bullet is attached to a long fine string and whirled round rapidly in a vertical plane, and the string is allowed to coil itself on a horizontal nail, the bullet will approach the nail in a spiral path, and it will be observed that the time occupied by the bullet in making a complete revolution about the nail diminishes as the bullet approaches the nail. It is not possible to arrange the experiment so as to make very accurate measurements, but roughly it can be seen that the area described by the radius vector from the nail to the bullet in any time is proportional to the time. The same principle explains the increasing rapidity of a dancer's pirouette, as he straightens himself up and draws in his limbs as close as possible to his axis of rotation.

It is important to observe that the law of equal areas holds, no matter what may be the shape of the path described or the intensity of the force, provided only that the force is constantly directed to the same point. The following experiment shows that the law of equal areas holds for a body describing an elliptic path under the action of a force varying directly as the distance, and directed, not to the focus of the ellipse, but to its center.

Let a vessel, having a small hole in its bottom, be filled with very fine sand, and suspended from a hook by a long string. If, now, the vessel is drawn aside from the vertical and swings round, the track made by the sand on the floor will be an ellipse. The force that constrains the vessel to move in an elliptic path is the horizontal component of gravity which is directed toward the center of the ellipse and is proportional to the distance of the vessel from the center. This highly instructive experiment was devised by Jeremiah Horrox, a very brilliant astronomer, and one of the earliest upholders of the Keplerian theories, who was born in Lancashire, England, in 1619, and died very suddenly on the 3d of January, 1640, in the twenty-second year of his age. When a planet is at the point of its orbit nearest to the sun it is said to be in *perihelion*, and when it is at the point most remote from the sun it is said to be in *aphelion*. It has been observed that the aphelia of the planetary orbits are not fixed, but have a slow progressive motion; the motion of the earth's aphelion has a period of about 108,000 years. Horrox was asked by his astronomical friend, William Crabtree, for an explanation of the motion of the aphelia of the planetary orbits, and he devised the experiment we have just quoted to explain it. In a general way this experiment illustrates the cause of the motion of the aphelia; although the orbit described by the vessel differs essentially from a planetary orbit in that it is described under the action of a force directed to the center of the ellipse and not to the focus.

The experiment shows that Horrox had a very clear idea of the way an orbit results from the combination of a projectile velocity and the action of a central force. The contemporaries of Newton could get no further than this, and it required his transcendent genius to discover the law of the force. Newton had studied attentively Horrox's contributions to the theory of the lunar motions, and always spoke of Horrox as a genius of the first rank.

It is easy to imagine a case in which an elliptic orbit is described by a body that is not acted on by a central force. For example, we can imagine a bead to slide on a perfectly smooth wire bent into the shape of an ellipse. In this case the constraining force, which at every point is normal to the ellipse, is not constantly directed to any one point, and therefore there is no equable description of areas.

When a bullet is whirled round in a circle at the end of a string, it tends to move in a straight line, in accordance with the first law of motion, and therefore it exerts a certain pull outward upon the string; this force with which the bullet tends to fly outward from the center about which it is revolving is called a *centrifugal* force; in order that the bullet may be constrained to move in a circle, its centrifugal force must be balanced by an equal and opposite pull inward upon the string, and this constraining force is called a *centripetal* force. The person holding the string is conscious of exerting this centripetal force, and it is evident that the string might be cut and the bullet continue to move in the same circle if the same force is applied to the bullet in any other way. By the law of centrifugal force, discovered independently by Newton and by Huygens, the magnitude of the centripetal force per unit of mass of a body revolving with uniform velocity v in a circle of radius r is $\frac{v^2}{r}$. Assuming the orbits of two planets to be circles, let f and f' represent the centripetal forces per unit mass acting on them, let v and v' denote their velocities, and let r and r' be the radii of their orbits.

Then, we have

$$f = \frac{v^2}{r}, \qquad (1)$$

and

$$f' = \frac{v'^2}{r}. \qquad (2)$$

Also, if T and T' are their periodic times, we have

$$Tv = 2\pi r, \qquad (3)$$

and

$$T'v' = 2\pi r'. \qquad (4)$$

From equation (3), we get

$$v^2 = \frac{4\pi^2 r^2}{T^2},$$

which, substituted in (1), gives

$$f = \frac{4\pi^2 r}{T^2}. \qquad (5)$$

In like manner, from (4) and (2), we get

$$f' = \frac{4\pi^2 r'}{T'^2}. \qquad (6)$$

Dividing (5) by (6), we have

$$\frac{f}{f'} = \frac{r}{r'} \times \frac{T'^2}{T^2}. \qquad (7)$$

Now, Kepler's third law asserts that

$$\frac{T'^2}{T^2} = \frac{r'^3}{r^3}. \qquad (8)$$

Substituting $\frac{r'^3}{r^3}$ for $\frac{T'^2}{T^2}$ in (7), we get

$$\frac{f}{f'} = \frac{r}{r'} \times \frac{r'^3}{r^3} = \frac{r'^2}{r^2}; \qquad (9)$$

that is,

$$f : f' = \frac{1}{r^2} : \frac{1}{r'^2}. \qquad (10)$$

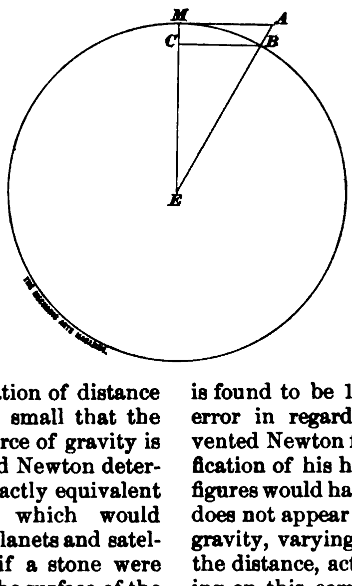
Therefore, if Kepler's third law is true for planets revolving in circular orbits, the force per unit mass acting on the planet must vary inversely as the square of its distance from the sun. It can also be proved that the same conclusion follows from Kepler's third law when applied to elliptic orbits, but the proof is somewhat mathematical.

So far as we know, no experiment has ever been devised in which a body is made to describe an orbit under the action of a force varying inversely as the square of the distance; but in the following experiment such a motion is imitated approximately. A small steel bead is suspended by a very long silk thread, and a powerful cylindrical magnet is placed upright vertically under the point of suspension. When the bead is drawn aside from the vertical and swung round, it describes an orbit under the action of a force directed toward the magnet. This force is made up of two parts: first, the magnetic attraction, which varies inversely as the square of the distance; and, second, the horizontal component of gravity, which varies directly as the distance. If the magnet is very powerful and if the thread is very long in comparison with the dimensions of the orbit described, the horizontal component of gravity is very small compared with the magnetic attraction. In this case, approximately, the bead describes an elliptic orbit under the action of a force varying inversely as the square of the distance and

directed toward the magnet, which is the focus of the ellipse.

From Kepler's three laws, therefore, it was clear to Newton that the motions of the solar system depended on a central force directed toward the sun and varying inversely as the square of the distance. In like manner the motion of a satellite is controlled by a central force directed toward its primary and varying inversely as the square of the distance.

It appears, then, that the motions of the planets and their satellites can be explained by such a hypothetical force as we have described; but the question yet remains, Is there actually such a force? The force of gravity, that causes the rain to fall and the waters of the rivers to flow down to the sea, had long been a subject of investigation by mathematicians and philosophers, and many of them had attempted to invoke this old familiar force in the solution of this very problem. It has sometimes been stated that Newton discovered gravity, but as a matter of fact, men in his time and before it talked as glibly as we do of the force of gravity. Galileo had discussed and established the laws of bodies falling freely under the action of gravity, but he had assumed that the force of gravity is constant, and his laws of falling bodies are true only when the variation of distance from the earth's center is so small that the consequent change in the force of gravity is insensible. How, then, could Newton determine whether gravity is exactly equivalent to the hypothetical force which would explain the motions of the planets and satellites? Newton knew that if a stone were projected horizontally near the surface of the earth the force of gravity would draw it down through a distance of 16 feet in one second. Now, if the moon behaves as a projectile acted on by gravity, and if gravity varies inversely as the square of the distance, then the distance through which the moon, in one second, is drawn toward the center of the earth, and away from its straight path, should be equal to 16 feet multiplied by the square of the ratio of the earth's radius to the radius of the moon's orbit. The moon's orbit is approximately a circle whose radius is 60 times the radius of the earth. Therefore, the moon ought to fall toward the earth $16 \times (\frac{1}{60})^2$ feet in a second, or 16 feet in a minute. Let the circle in the figure represent the moon's orbit, E being the center of the earth and M the center of the moon. If the moon were not acted on by any force it would move along the tangent to the circle at M, and a minute later it would reach the position A; but being acted on by a force to the center of the earth, it actually arrives at a point on the circle that coincides very approximately with the point B, having been drawn toward the earth through the distance $A\,B$. Since the arc $M\,B$ is very small, the distance $A\,B$ is nearly equal to $M\,C$, which is the versine of the arc $M\,B$. The periodic time of the moon is 39,343 minutes, and therefore, if we denote the radius of the earth by a, the moon in one minute describes an arc equal to $2\pi \times 60\,a \div 39{,}343$.



If, then, the earth's radius is known, the arc $M\,B$ and its versine $M\,C$ can be calculated. Newton, in 1666, assumed that a degree of latitude on the earth's surface measures 60 miles—whereas it actually measures 69½ miles—whence he calculated the earth's radius to be 3,400 miles, instead of the correct value, which is almost 4,000 miles. With his erroneous data, Newton found $M\,C$ to be 13.9 feet, instead of 16 feet. Taking 4,000 miles as the earth's radius, $M\,C$ is found to be 16 feet almost exactly. This error in regard to the earth's radius prevented Newton from obtaining the clear verification of his hypothesis, which the correct figures would have given; yet the discrepancy does not appear to have shaken his faith that gravity, varying inversely as the square of the distance, acted on the moon. Commenting on this computation, by which he compared the force requisite to keep the moon in her orbit with terrestrial gravity, he says he found they corresponded pretty nearly. William Whiston, who succeeded Newton as Lucasian professor of mathematics at Cambridge, in his "Memoirs of His Own Life," has given notes of a conversation that he had with Newton, in which Newton intimated that he considered it possible that some other force acted on the moon as well as gravity; this other force he imagined might be Descartes's vortices. This account is confirmed by Pemberton, who acted as

editor of the third edition of Newton's Principia.

At this time Newton was absorbed in other studies, and attached very little importance to his investigations with regard to gravitation. The computation referred to was made when he was in the country and had not access to books, yet he laid it aside for years and made no attempt to check the calculation when he returned to Cambridge, where he could have obtained a more correct measurement of the earth. Both Pemberton and Whiston state expressly that Newton was disappointed with the verification the computation gave to his hypothesis; and that some time afterward, when M. Picartt, in France, had more accurately measured a degree of latitude and found it to be 69½ miles, Newton renewed his calculation and found the verification of his hypothesis completed. The late Prof. John Couch Adams, than whom none was more competent to form a judgment, said that Pemberton and Whiston were mistaken in supposing that Newton was disappointed. Newton knew that the orbit was not truly circular and that his numerical data were not exact, and it would have been absurd for him to expect anything more than a rough verification of the hypothesis. Prof. Adams maintains that, in 1666, Newton was convinced that gravity alone holds the moon in her orbit, and that gravity is due to the fact that every particle of matter attracts every other particle with a force that varies directly as the product of their masses and inversely as the square of the distance between them. Fortunately, the question is of little importance, for there is no doubt about the conclusion to which he finally came.

With regard to the attempted verification, we may add that when the earth's radius is taken as 4,000 miles, the calculated value of the versine MC agrees closely with that required by the hypothesis; but when the most accurate modern value of the earth's radius is taken, the agreement is only approximate. This is due to the fact that the moon is subject to great disturbing forces and therefore its orbit differs considerably from that which it would describe if acted on by the earth's attraction alone.

At this time Newton had discovered that the planetary motions are governed by a central force varying inversely as the square of the distance; but the general opinion, from which Prof. Adams is a solitary, though very formidable dissentient, is that he did not know that this force is gravity alone. From Kepler's third law it follows, as we have seen, that the force that holds the planets in their orbits, whatever it may be, is exerted on all the planets alike, and is not elective, like magnetic or chemical attraction. If the earth were taken from its orbit and launched into the orbit of any other planet with that planet's velocity and direction in that part of the orbit, the earth would describe the same orbit as that planet in the same time, and at each point would have the same velocity. This statement requires a minute correction, due to the difference between the mass of the earth and the mass of the planet.

In these investigations Newton treated the sun, planets, and satellites as bodies so small that their dimensions could be neglected in comparison with the distances between them; he did not yet know how to determine the attraction of a solid body on an external particle, nor did he know that the earth's attraction was directed exactly to its center. Indeed, the investigations of 1666 had scarcely touched upon the edge of this great subject, and would long since have been buried in oblivion, but for his later researches. Newton's friends, who were associated with him in his mathematical and scientific labors, attach very little importance to his work on gravity in 1666, and have given very meager accounts of it, rightly considering that the important events of Newton's career at this period were his discoveries in pure mathematics and in optics. Yet this is the step in Newton's discovery to which popular writers have given most notice, and many of them have ignored completely all the other far more important steps.

As to the origin of these investigations, Pemberton, speaking from Newton himself, says that his thoughts first turned to the subject while meditating in a garden, but no mention is made of any apple falling. One of the authorities for the apple story is Mr. Robert Greene, M. A., who is remembered chiefly as the author of a treatise on "Solid Geometry," of which a competent critic says, "the gentleman has been reputed mad for these two years past, but never gave the world such ample testimony of it before." Mr. Greene also published another treatise of 981 folio pages, in which he proved to his own satisfaction that the circumference of a circle is equal to 3½ times its diameter. Voltaire, who did much to introduce the Newtonian philosophy into France, states, on the authority of Mrs. Conduitt, Newton's niece, that Newton was led to

think of gravitation by the fall of an apple. The story is also found among the papers of Mr. Conduitt, who was Newton's assistant at the Mint, in the draft of a memorandum prepared to be sent to Fontenelle, in France. But Fontenelle, though a great retailer of anecdote, does not mention it, and therefore there is reason to suspect that Conduitt omitted it from the memorandum sent to France. D'Israeli works a little more artistic detail into the story: "the apple," he says, "struck him a smart blow on the head; he was surprised at the force of the stroke, and this led him to consider the accelerating motion of falling bodies." No doubt a phrenologist would say that the apple, under the guidance of Minerva, struck him exactly on the bump of causality.

In addition to these eminent authorities, the story received strong confirmation from the fact that there was an apple tree actually growing at Woolsthorpe, until it died, in 1820. Sir David Brewster, who has written a life of Newton, brought away a piece of a root of the tree in 1814; but history does not record whether this was the cause of its death or not. Some authors are not content with a single apple, but speak of a shower of small apples. Every version of the story can be traced directly to Newton's favorite niece, Mrs. Conduitt, who lived with him in his old age. It is certain that she did not invent a false story; but it is to be remembered that a lady of that time would certainly not have the training or knowledge that would enable her to understand the steps by which Newton was led up to the law of gravitation; it is probable that Newton, in explaining his discovery to her, used the fall of an apple as an illustration; and, between Mrs. Conduitt and the authors who have used the story since, it has acquired an undue importance. The fact is that Newton could not have avoided thinking of this problem, unless he had been able to cut himself off from all reading of scientific books, and from all communication with his scientific contemporaries.

This closes the history of the investigations in the year 1666; we have yet to speak of the incomparably more brilliant and important chain of reasoning and calculation by which Newton finally established, as a law of the universe, the doctrine that in 1666 was merely a plausible hypothesis, supported by a solitary very incomplete verification. Newton never evinced undue haste in publishing his discoveries, and it was not until many years afterward that any one knew of what he had been doing.

THE GEOLOGY OF THE WEST.

Prof. Arthur Lakes.

CHARACTERISTIC FEATURES—THE LARAMIE FORMATION—THE GREAT TERTIARY LAKE. RESEARCHES OF PROFESSOR MARSH.

WITH many others who took advantage of cut rates, we have just returned from a flying trip to California. Our route, both ways, was by the Central Union Pacific Railroad. The scenery of four-fifths of the journey may be briefly described as alkali, rocks, and sage brush, with the occasional absence of sage brush; this describes Wyoming and the greater portion of Utah. The other one-fifth is the oasis around Ogden, and the Wasatch Range in Utah, and, finally, the paradise of California, which rewards our three days of desert traveling.

Desolate and monotonous in the extreme as is so large a portion of the route, it yet affords a certain interest to the traveler, who perhaps for the first time in his life views a real desert, while to the geologist the whole journey is fraught with peculiar interest. In less than three days he traverses, views, and traces the structure and history of the most important part of this continent, its extreme barrenness enabling him to see the anatomy of the rocky skeleton here laid bare, but which in other regions is usually concealed with verdure.

For others that may take a similar journey, we offer a sketch that may break the monotony of alkali, sage brush, and rocks that are constantly flitting past their windows, and infuse them with a lively interest in passing scenes by describing something of their history, and recounting the wonders that lie beneath the surface.

From Denver to Cheyenne the prairie is a flat table, and would also come under the ban of alkali, sage brush, and rocks were it not that the two centers of civilization,

Denver and Greeley, have spread out their arms in a network of irrigating ditches over it, and converted the desolate prairie, to within a few miles of Cheyenne, into a long strip of farms and farm land.

The waters of the Platte, the St. Vrain, and the Cache le Poudre Rivers have all been made to contribute to irrigation, and the result is a series of thriving little towns, extending all along the once desolate path of the Union Pacific Railroad. Some forty miles to the west of us, parallel to the route, are the snow-capped mountains, which attain their highest elevation opposite Denver, averaging 14,000 feet, and dwindle in height and break up into low ranges as we near Cheyenne, Wyoming.

The flat surface we have traveled over is covered with a few feet of drift pebbles, carried from the granite mountains by the large bodies of water that covered this area after the melting of the glaciers that at one time occupied every cañon and ravine in the Rockies in the glacial epoch.

Immediately below the surface drift lies the coal strata of Colorado ; then a series of sandstones, containing many fossil leaves of tropical vegetation, together with several valuable seams of coal at greater depths. These deposits were formed by a lake of Upper Cretaceous times, whose banks and islands were covered with tropical vegetation, such as palmetto, fig, plane, magnolia, sassafras, and sweet-gum trees. As these beds are best developed in the great plains around Laramie City, where they form extensive tablelands over a large portion of Eastern and Western Wyoming, geologists have named it the Laramie formation. From this formation, throughout Colorado, Wyoming, and Utah, our Western coal is mined. Below this, underlying the prairie, an Artesian well would show the successive formations composing the earth's crust, until finally bed-rock granite would be reached.

It may seem strange that a region but lately so desolate and void of water, once bloomed with the rampant vegetation of the tropics, and was covered with more water than necessary for farming, since a succession of enormous lakes extended pretty nearly from the Rocky Mountains to beyond Omaha. Now, again, after millions of years of aridity, the vast waste is being partially restored to its former fertility by the hand of man, and it has a vegetation very different, but much more useful, than that with which nature originally clothed it.

We cross the boundary of Colorado and enter Wyoming near Cheyenne. Nature has done little and can do little for this important city, situated on an arid plain. Its growth is a result of an artificial civilization dependent more or less on the Union Pacific Railroad. Now the track ascends slightly, till at Sherman, about 10,000 feet above sea level, we cross the top of a low spur of the Rocky Mountains, which is continued in a northeasterly direction, in what is called the Black Hills of Laramie. As far as the eye can reach we see tableland after tableland of sandstone of the Laramie coal formation. A continuation of the great Cretaceous lake and its beds has been tilted up on either side of the Black Hills, leaving the under formation exposed, some of which is of a brick-red color, called the Triassic. Wyoming has a much more rolling bluff and tableland character than our Colorado prairies, and it is between these bluffs and tablelands, in the bottoms occupied by streams, that such vast herds of cattle derive sustenance and protection, and which has made it a great cattle-raising country. The rolling character is due apparently to the disturbance caused by the uprising of the Black Hills, which has crushed and folded the underlying strata into gentle undulations between it and the Wasatch Range. To the west the tablelands result from ancient as well as modern drainage of the country cutting up the horizontal strata by ever widening ravines.

To a geologist, one of the first and most interesting localities along the route is at Como Station, now called Aurora, where the strata have been folded up and cut by erosion into bluffs. Here the writer spent a year for Professor Marsh, excavating huge fossil lizards from the bluffs in the vicinity. The remains of these animals were found sticking out of the clay of the bluffs, or portions of them had rolled down from above and were lying at their bases; the bones were black with iron oxide, and completely turned to stone. Many carloads of bones of these and several other varieties of animals that were found were sent to the Yale Museum. Some of these great lizards were from 50 to 60 feet in length, and stood as high as 25 feet, as is shown by their colossal limbs ; the thigh of one measured 8 feet in length, while the size and length of the body and the enormous tail may be estimated by the great vertebræ found, some of which were 12 to 20 inches in diameter, resembling an ordinary buffet, or small barrel. The heads were small and lizard-like. We might compare them to gigantic

alligators, walking on tall, massive legs like an elephant. The feet were armed with claws; the jaws contained a number of teeth, some 6 inches in length, and were spoon-shaped in one species, showing their diet was herbivorous. In others, the bones were lighter and hollow; the hind legs were much longer than the fore legs, showing that the animal was more like a kangaroo, and progressed by leaps. The jaws were armed with formidable saber-shaped teeth, while the claws were long, sharp, and curved, proving its habits to have been carnivorous. Another species, some 40 to 60 feet long, was covered with plates of armor, like a tortoise, and along the crest and the back extended a series of long, sharp spines, two feet in length, and six or eight inches wide at the butt. It must have resembled a gigantic horned toad, only that its hind feet were very much longer than its fore limbs, hence it must have also, at times, walked kangaroo-fashion; its spoon-shaped teeth showed it to have been herbivorous. Besides these were several much smaller species, no larger than a cat, but also of the kangaroo type. Several small mammals, allied to the kangaroo family, were discovered, and also a fossil pterodactyl. All of these are now in the Yale Museum. Looking out on these desolate stations a fellow traveler remarked, "If I were condemned for a crime and had my choice of life at the penitentiary or at one of these stations, I would take the penitentiary every time." The writer has been through the mill and has a lively recollection of the utter desolation of these spots, especially in winter; for days together the station, not 50 yards distant, was invisible to us in the perpetual blizzard, and, with the thermometer 30° below zero, we hugged a red-hot stove, and fried on one side and froze on the other; the only music to relieve the monotony was the chorus of coyotes after sunset, and ideas and conversation seemed to cease for lack of material and ordinary interest. The only redeeming feature was a certain indescribable charm of wildness; outside of that and our scientific interests, we were inclined to agree with the traveler, or with one of the party, who said, "such a region is only fit for the departed spirits of the Indians." But night throws a veil over the scene, and then we pass Freeze-Out Mountain, Red Desert, and other charming spots, and on awakening next morning we are still looking out on alkali, sage brush, and rocks. There is a little more rock, however, as the names of the stations imply: Black Buttes, Point of Rocks, Rock Springs, etc., for we are passing through a thick section of the Laramie coal formation. Strata upon strata of brown sandstone, dipping at a moderate angle to the northeast, appear on either side of the track, and below and between them flows the sluggish Green River; but occasionally over the rampart of stone we get glimpses of similar endless bluffs and tablelands of the same formation.

We are now entering a coal district, and are not surprised to see several outcrops of coal along the side of the track, or exposed in the cliffs, and presently reach Rock Springs, an important coal-mining town. Here are several seams of coal of excellent quality, some of great thickness. As many as seventeen have been pierced by a bore hole. Evanston, some miles farther on, and Rock Springs, are the principal coaling districts of the Union Pacific Railroad in this region. Had we time to stop we could procure from these desolate bluffs an ample collection of the abundant and luxurious vegetation that once grew here and is now entombed in stone; but the train carries us on to a slightly different region; the great brown sandstones dip below, and are covered over by beds of an ashen-gray and greenish color. They are perfectly horizontal, and it needs little imagination to conceive that here is the relic of another great lake of more recent origin, formed on the partially upturned backs of its predecessors, the Laramie lake beds. The Green River cuts through this soft formation, and has molded it into all sorts of monuments and grotesque forms, besides dividing it up into a labyrinth of tablelands, crowned with isolated castles and round towers of sandstone of red, gray, and green colors, like the ruins of some city of the dead.

Again, as we look north, as far as the eye can reach stretches this dreary but singular labyrinth of tables and castles and monuments of fantastic shapes, all of clay and sandstone, and we get some idea of what a vast area this more modern Tertiary lake covered, and how long its continuance must have been over this area to accumulate such a thickness of sediment, since Green River, close to us, cuts 600 feet into it, and yet there is no sign of bottom to the sediment.

Professor Marsh, of Yale, who was the first to scientifically explore this remarkable region, estimates the lake or series of lakes to have extended over 100 miles, and to have accumulated sediment two miles in vertical depth. For what a vast period of time

must these lakes have existed to deposit such a thickness of material! This material was derived from the Wasatch Range on the west, the Uintah Chain on the south, and the Wind River Range on the north. All this sediment was robbed from these mountains and brought in by ancient rivers and deposited in this lake. This lake basin, which is now 8,000 feet above the sea, has since suffered by erosion, and half its original thickness has been washed down the Colorado River, of which the Green River, which drains the area, is a tributary. This same washing-away action has brought to light the remains of many extraordinary extinct animals whose remains were first discovered by Professor Marsh, projecting from the sides and cliffs of the curious tablelands. Many of them nearly equaled the elephant in size, while in other respects, though they were the ancestors of the present fauna, they can scarcely be compared with anything now living. These gigantic beasts, judging from the abundance of their remains, must have roamed in great numbers about the borders of this ancient tropical lake.

As we look from the train over the singular "bad lands" we see that it is a region destitute of vegetation, without water, and without a green thing to refresh the eye except sage brush. Nothing but fantastic and monotonous cliffs, scorched and bleached by the summer sun and winter blizzards, meet the eye, and when the wind blows they are covered with alkaline dust that is burning to the eyes and scorching to the lips; in short, it is a region utterly solitary and desolate, and we may well admire the enthusiasm for research that prompted Professor Marsh, to whom is due the discovery and determination of these strange creatures, from 1871 to 1875 to make five expeditions under military escort into this repulsive desert. His discoveries will make his name illustrious in the scientific world.

Among the animals found were the now celebrated ancestors of the horse, the eo-, plio-, and mio-hippus—little horses with from three to five toes, very unlike our modern ones. The three mentioned take their names from the ancient lakes in which they were found. Ancestors of the tapir, pig, and monkey were found; also various carnivorous and insect-eating animals, rodents, and little animals like kangaroos. Crocodiles, tortoises, lizards, serpents, and fishes were found, as might be expected, in abundance, while palm leaves and the remains of other tropical vegetation that grew around the banks of these lakes were dug up. One of the most extraordinary and gigantic creatures, nearly the size of an elephant, but more like a rhinoceros, was dug out, called the dinosaur, or terrible horned beast. It carried no less that six rhinoceros horns in three separate pairs from its forehead to its snout, and besides this its jaw was armed with two long downward-pointing tusks, like the sea horse or the walrus.

Professor Marsh recognizes in this region a succession of three lakes, the Eocene, the Miocene, and the Pliocene, one superimposed at different times above the other, and each characterized by distinctive animals. Collectively, these deposits reach a depth of two miles. The history of this region he gives as follows: The Eocene lake basins lie between the Wasatch on the west, and the Rocky Mountains on the east, on the high central plateau of the continent. As these mountain chains were elevated, the enclosed Cretaceous sea, cut off from the ocean, gradually freshened and formed these extensive lakes, while the surrounding land was covered by a rich tropical vegetation and with many strange forms of animal life. As the upward movement continued, these lake basins, which for ages had been filling up, preserving a faithful record of their life's history, were slowly drained by the deepening of the outflowing rivers, and have since remained dry.

The Miocene lake basin was on the flank of this region, where the land had been only since the Cretaceous times. It contains the remains of another monster, the brontotherium, and also the remains of the oriodon and of the Miocene horse. The climate was warm.

The Pliocene lake rests uncomformably on the Miocene, and is also full of strange animals, among them being horses more like our modern ones.

Such is the life and geological history of these barren tablelands, so strange in form and color, through which we pass on the Union Pacific Railroad; a cemetery of the dead past, now arid, lifeless, treeless, once overflowing with water, tropically fertile, and crowded with strange forms of life. At Green River we stop for the best breakfast on the road, and the train hurries on to Evanston, another important coal-mining center, but as unpicturesque and uninteresting as such districts usually are. We are now on the borders of Utah, and in our next article shall enter it through the fine Echo and Weber cañons, which cut through the heart of the Wasatch Range.

(To be Continued.)

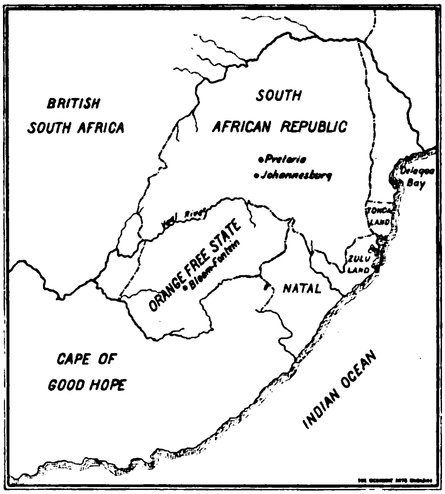
CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Transvaal.

THE correct name of the state commonly known as the Transvaal is the South African Republic. It is divided from its sister government, the Orange Free State, by the river Vaal, and the two lie like an island surrounded on all sides by the British possessions in South Africa.

It is well known that there has been a difficulty of many years' standing between Great Britain and the South African Republic, and American sympathy has been freely extended to the weaker party. This is quite natural, for two reasons. In the first place, there is a traditional belief in this country that Great Britain is generally in the wrong in her international relations with her neighbors (except with the United States in the year of grace 1898!), and that she is always the aggressor if a difficulty arises between her and a weaker state. This is a hereditary condition of mind that has survived through several generations. The fact that American citizens have been fellow sufferers with British subjects in the Transvaal may have helped to undermine the constitution of this lusty prejudice; but it dies hard. In the second place, the Transvaal is in name a republic; and it is natural that the Great Republic should side with a small sister in her conflict with "an effete monarchy." But it is possible for a state to have the name and not the nature of a republic. Americans believe that governments receive their just powers from the consent of the governed. Webster defines a republic as a state "in which the sovereign power resides in the whole body of the people"; and he goes on to say that "no existing republic recognizes an exclusive privilege of any class to govern." Tried by these standards, the government of the Transvaal, for fifteen years past, has been a despotism with Mr. Kruger at its head; for this clever and obstinate old politician, who tied up his bundle of prejudices fifty years ago, holds the Transvaal Boers in the hollow of his hand, and his will is their will. At best it may be called an oligarchy, "a form of government in which the supreme power is placed in the hands of a few persons"; for the Boers, who form 27 per cent. of the white population, make laws for 73 per cent., who are Uitlanders (Outlanders, or foreigners), depriving them of all political power.



Now, there is, of course, a reason for this state of things in the history of the country, and it may be briefly outlined. The Dutch settlements in South Africa began in 1652, and spread slowly until the beginning of this century. One of the results of the wars which convulsed Europe at that date was the cession by Holland to Great Britain of her South African possessions. The independent Dutch settlers had been restless under the government of their own people, and did not take kindly to their new rulers. They were for the most part ignorant; by nature they were unprogressive and disinclined to change; and, scattered thinly over a wide territory, had little of the contact with their kind which sharpens men's wits and promotes healthy growth. The British made injudicious changes in methods of government; they enforced a stricter rule than had existed before; they substituted English, which few could understand, for the Dutch language in legal proceedings; and they occasionally protected the natives in the numerous wars between the whites and the neighboring Kaffir tribes. To the great indignation of the Boers, they were checked in their harsh and cruel treatment of their

Hottentot slaves. These slaves were finally emancipated by the British, to the serious loss of their owners, many of whom were thus deprived of the bulk of their property, and received inadequate compensation. This action was universally resented by the injured class who believed slavery to be a divine institution; and smarting under what they felt to be unjust treatment, the Boers emigrated in numerous small parties into the wilderness to the north of the Vaal. Paul Kruger, then a child ten years old, was with one of the groups that traveled north in 1836, the pioneers of nearly ten thousand who followed in the course of the next ten years. The British still regarded them as subjects, while the Boers claimed to set up a government of their own, which was very loosely organized. The main bond between their small scattered communities was their spirit of hostility to the British, who cared little what they did, so long as they did not stir up trouble with the natives.

In 1852 the Boer government was recognized, and the right to manage their own affairs without interference was guaranteed by the British, on condition that alliances should not be made with other nations, and that slavery should neither be permitted nor practiced. Disorder prevailed in the new republic. There were some internal dissensions, but the main trouble arose from incessant conflicts with the native tribes. The farming Boers would not pay taxes; there were therefore no public funds with which to provide for the public needs or defenses of the country. By 1877 the disturbances had become a source of danger to British settlers in and near the Transvaal, the state was bankrupt, and trade had ceased. Kaffirs and Zulus threatened to overwhelm the whites. At this juncture the British commissioner proclaimed the annexation of the Transvaal to the British crown, a step which, while it provoked protest from the Boer leaders, was accepted with little resistance by the people, who felt that they were not strong enough for self-protection from their savage neighbors.

The policy then pursued by the British showed a lack of sound judgment, and ignorance or disregard of the wishes and needs of the Boer people. However, they subdued the native tribes who had terrorized the community, and restored the peaceful conditions under which alone an agricultural people can thrive. But no sooner was the pressure of this danger removed than the Boers threw off the British rule, which had been submitted to by some and accepted by others. They rose in arms at the end of 1880, attacked the few troops that could hastily be concentrated from the small detachments scattered here and there in the Transvaal, and were victorious, inflicting considerable loss. The British government, always indifferent to its South African colonies, and especially so under the ministry of Mr. Gladstone, who was then in power, made little further effort. Reenforcements had been despatched from England, but while they were on their way terms of peace were concluded, recognizing the self-government of the Transvaal, under the suzerainty of the Queen, who reserved the right to control its relations with foreign powers.

The Boers, as might be expected from an ignorant people, could see neither policy nor magnanimity in the concessions made to them by Great Britain, but flushed with victory they thought that they were invincible, and that the paramount power had yielded from fear. They forgot, or perhaps could not understand, that the British, whose white South African subjects were more than half Dutchmen, had no desire to make hard terms with other Dutch settlers. A sterner policy might have been more prudent, for the Boers have persistently used their independence to the injury of British subjects who have settled in their territory, and have stirred up sedition among the Dutch element in the other South African States.

The discovery of extensive gold fields within the Transvaal led to the influx of great numbers of strangers, most of whom were British or Americans. Fearing that these newcomers, who expected to become permanent residents, would introduce changes into the old-fashioned Boer mode of government, the laws relating to the franchise were altered repeatedly, until at length the voting power was practically restricted to the Boers themselves. The Uitlanders had settled in the Transvaal under the guarantee of a liberal constitution; they had invested many millions sterling of capital; and they naturally resented the subserviency of their position, and the disadvantages to which they were exposed by the new franchise laws. After repeated efforts and appeals they were so misguided as to attempt a resort to force, thus putting themselves hopelessly in the wrong. A rising took place in December, 1895, which was ill managed and met with deserved defeat, though scarcely a blow was struck. This was the

much-talked-of Jameson raid, in which about five hundred Uitlanders took part. For injuries caused by this raid, which lasted four days, and in which five Boers were killed and three wounded, Mr. Kruger has presented to the British government a neat little bill, amounting to $8,390,000, of which $5,000,000 is assessed for "moral or intellectual damages"; in other words, he proposes to collect this sum as a fine. The item for "moral damage" is the more preposterous on account of the frequency with which Boers themselves have made raids into British territory in the past. The bill has not been paid. After the raid, reforms were again promised by Mr. Kruger, but like all other pledges of a similar character they have proved to be wholly fictitious, and the condition of the Uitlanders is worse than ever. The large majority of them are British subjects, and they have now made an urgent appeal to their own country to redress their grievances.

What are the grievances of which the Uitlanders complain? They form nearly three-fourths of the inhabitants of the Transvaal, and pay about nine-tenths of the taxes, at an average of $80 per head of the Uitlander population. They have no voice in the expenditure or the levying of these taxes, which are laid with careful discrimination on articles used by the Uitlanders but not by the Boers; they have no power in the government of their town, Johannesburg, in which more than 50,000 of them reside, and where common sanitary rules cannot be enforced; no control of public education, which even in the Uitlander district is mainly conducted in the Dutch patois spoken in the country; no freedom of the press; no right of public meeting; no representation on juries nor on the police force; no right of citizenship even for their children born in the republic; they are subject to expulsion from the country without any form of trial; their town is controlled by a ring of fortifications recently built on the surrounding hills; acts of violence against their property and their persons are committed with impunity; and articles of the constitution can be altered hastily by the Volksraad, whose decisions are not now subject to revision by the so-called Supreme Court, which within the past three years has been deprived of its most essential functions.

Sir Alfred Milner, representing the British government, has lately held a conference with Mr. Kruger in the hope of securing justice for this large section of the Transvaal population. He wisely went to the root of the matter, and endeavored to secure for them a reasonable representation in the government by a readjustment of the franchise, knowing that separate grievances could thus be gradually but surely redressed. Unfortunately, the Transvaal government in the past has frequently broken its contracts, and gone back on its word in many ways, by introducing changes into the franchise laws as soon as the Uitlanders appeared likely to gain advantage from them. It therefore becomes necessary to secure a guarantee of good faith and permanency before they can be trusted by a people that in the past have seen solemn engagements ignored or violated. A few of the changes that have been made may be indicated. In 1876 the custom common to South Africa prevailed in the Transvaal; that is, the requirements for citizenship were one year's residence, possession of a certain amount of property, obedience to laws, and good behavior. In 1882 the conditions were five years residence, with liability to military service, after giving notice of desire for naturalization; a strict form of oath; and a fee of $125. Since then, the attainment of citizenship by the Uitlander has year by year become more difficult until, as matters stand now, no alien can obtain equal rights with the burghers unless, being forty years of age, he has resided in the country for fourteen years, has severed relations with any other country for at least twelve years, possesses a moderate fixed amount of property, has rendered military service, and has received the consent of two-thirds of all the burghers of his district to his enfranchisement. This last condition is a practical prohibition, for such a proportion of votes is never cast at any election.

Sir Alfred Milner proposes on behalf of the Uitlanders that any man of good character who possesses the requisite property qualification, has resided in the Transvaal for five years, and has taken the oath of allegiance, shall be able to obtain a vote. He also demands a redistribution of seats in the Raad. The Boer population is so scattered, and the Uitlander population is so concentrated in the towns in the vicinity of the mining districts, that at present, if the latter had full voting powers, they could secure only two seats in the Raad of twenty-eight members, with a bare possibility of two more. With more than two-thirds of the population, they ask for one-third or one-quarter of the representation, which will

give them a substantial minority to present their views in the Raad. Up to the time of writing (September 1st) these demands have been refused.

The position in which the Transvaal government has placed the Uitlander is a distinct violation in letter and in spirit of repeated treaties made with Great Britain since 1852. The aim of each of these treaties has been to secure that equality of rights for white men in the Transvaal which is the rule everywhere else in South Africa, in the Orange Free State, which is an independent Dutch republic, as well as in the British colonies. For twenty-five years British subjects settling in the Transvaal were on the same footing as burghers, and in the convention of 1881 it was stipulated and agreed that equal privileges and protection should be enjoyed by all. The radical alteration of the system was introduced in 1890, and is thus less than ten years old, and in every respect an innovation. The Uitlanders went to the Transvaal as settlers under certain conditions, which have been arbitrarily altered: they went depending on the good faith of pledges, which have not been fulfilled. The Transvaal government (which is only another name for Mr. Kruger) has thus deliberately decided that a large majority of the population shall retain their allegiance as subjects of a foreign power. Every possible obstacle has been put in their way when they have desired to become citizens. As foreign subjects they have no choice but to appeal to their own government when they believe themselves to be wronged. They have no claim on the Transvaal, no legal means of approaching its authorities when they seek redress. As citizens or burghers they could have recourse to constitutional means, and no other government would have a right to interfere.

There is no proposition for annexation of the Transvaal by Great Britain at present. South Africans look forward to a federation of states in that region, of which Great Britain would be—as she now is—the predominant power; but there is no reason why Anglo-Saxons and Dutchmen should not live side by side in harmony and confidence in such a federation, with a mutual respect for each other's rights and each other's authority, such as now prevails everywhere except in the Transvaal. The intrigues that are being carried on among her Dutch subjects in Cape Colony and elsewhere may compel Great Britain to interfere. It is evident that she is unwilling to resort to force, for otherwise war would have been declared long ago; and the mixed population of her South African colonies has much to do with this reluctance. British and Dutch live in absolute equality under her colonial laws; they share in the government and are as one people. Great Britain cannot afford to have antagonism aroused between the two races which are so closely intermingled. Such antagonism is being stirred up by the Boers by every means in their power, to the great danger of their own state. Persistence in such tactics must result in war, which would surely end in the annexation of their country by the stronger power, and the loss of their independence. Neither need be endangered if the South African Republic is worthy of her name, and becomes actually, as well as nominally, a free government of the people, by the people, and for the people.

PRINTING IN COLORS.

THERE has recently been set up in London a machine for printing in colors by a new method. The machine is the invention of Mr. Ivan Orloff, manager of the Russian government printing works at St. Petersburg, and is said to be very successful. A company has been formed to develop the use of the machine, which it is claimed will revolutionize the production of colored illustrations for books and magazines. In the usual method of printing colored illustrations, the colors are applied successively, and each must be perfectly dry before the next is applied. In the Orloff machine, separate blocks—one for each color—are arranged around a cylinder. As this cylinder revolves, an ingenious system of cams causes a roller bearing the colored ink required by each block to come in contact with the block. A single revolution of the cylinder inks all the blocks. As soon as the blocks are inked, they transfer their ink to a composition roller; this composition roller transfers the combined colored design to a *form* carried on the same cylinder as the separate blocks. From this form the colored picture is printed at a single impression, no matter how many colors it contains. The cylinder makes a revolution in three seconds, and the form is then ready to print the colored picture.

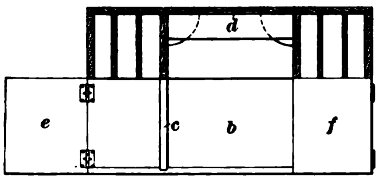
GOOD SCHEMES

PHOTOGRAPHIC DEVELOPING STAND.

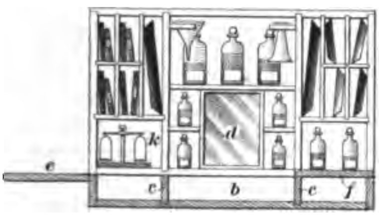
L. A. O.

SEVERAL OF the photographic magazines have lately published short articles on the convenience and value of a certain style of developing stand, and although some of the articles have been illustrated, none of them so far have printed a full set of working drawings from which to construct the stand.

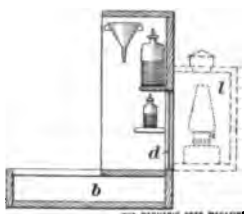
In the figure is shown at (a) the front elevation, at (b) the plan, and at (c) a side elevation and section of the most suitable form of this developing stand. A rectangular frame, 1 foot 9 inches high, 3 feet long, and 9 feet deep, stands over a shallow tray b, the latter being the same size as the frame, but only



(b)



(a)



(c)

4 feet deep. The inside of the frame is divided by shelves and partitions into several compartments, as shown in the figure, and at the back an $8'' \times 10''$ window d is glazed with deep ruby glass, through which the light enters when the plate is being developed.

The tray is divided into three compartments by the partitions c. Hinged covers close over the outside compartments, so that a developing tray may be set in one of them and closed up, in case daylight is required for some other purpose. The covers of these compartments, when open, provide a shelf at each end of the stand, as shown at e, and when closed may be used as a shelf to operate on within the lines of the frame, as shown at f. In the compartments on the right side of the vertical frame, provision is made for three sizes of developing trays and three bottles of chemicals. On the left side are stored plates, printing frames and paper, powdered chemicals, etc., and the middle portion is reserved for solutions required for most frequent use. On the narrow shelf, immediately over the window d, are the developing, intensifying, and reducing solutions; and on the single shelves, to the right and left of the window, are the restrainers, accelerators, etc. At the top of the central compartment are brackets to receive funnels, glass graduates, etc., and in compartment k are the hydrometer, scales, etc.

This developing frame may be placed against a window in an ordinary room, and all light, except that which passes through the pane d, shut out; or it may be used at night, with a lamp enclosed in a box behind the pane d, as shown dotted at l.

This tray and vertical frame has every convenience of a photographic dark room, except running water, and even this may be supplied if there is a faucet in the room where it is used. The author uses a common faucet connected through the back of the central tray, which is zinc-lined in this case, and attaches it by a rubber hose to the faucet at the wash basin. In fact, on sultry summer evenings it is a most handy device to take outdoors and attach the tray faucet to the garden hose. Development of pictures, under these circumstances, can proceed with all dark-room conveniences, and at the same time avoid all its annoyances of heat and cramped positions. When not in use, the tray may be removed from the vertical frame, and, as its outside dimensions are the same size, it can be hooked over the front of the former to protect the contents from dust. The whole outfit may then be stored away, occupying a space of less than 6 cubic feet.

CROSS-SECTIONING DRAWINGS.

R. C. Davison, New York City, N. Y.

I NOTICED in your April issue an article that describes a device for cross-sectioning. I have tried many devices and at last have found a method that seems easier and quicker than any I have used before. It is simply this: I do not attempt to cross-section my original drawing with any amount of accuracy, but on tracing it I insert a piece of cross-sectioning paper under the parts to be cross-sectioned. This has lines about $\frac{1}{16}$ inch apart. If the sectioning is to be fine, I trace every one; if coarse, I skip one or even two lines, as the case may be.

UTILIZING SHORT PIPE ENDS.

"Observer," Cleveland, Ohio.

SHORT ENDS of pipe may, instead of finding their way to the scrap heap, be utilized for nipples. To do this, provide a suitable place where they can be stored until the accumulation is sufficient to commence on. In making a lot of them at once, it pays to go about it in a practical and systematic manner, and the result will be a ready stock of nipples of various lengths, well threaded, and much superior even to the ordinary commercial article. Whoever has had occasion to make a short nipple now and then, in an ordinary machine shop, will appreciate this.

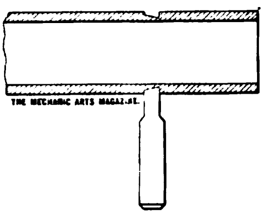


FIG. 1.

To do the work of cutting off in the best way, a cutting-off machine of the power type is preferred; the cutting-off tool should be ground so as to present an angular face to the cut, as shown in Fig. 1, which will cut through first on the projecting end, making

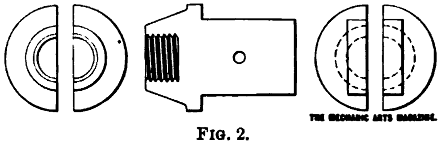


FIG. 2.

a complete finished surface at the end thus cut off, and without the burr, ragged, or bent edge so often noticed in pipework, due to the ordinary way of cutting off. For cutting the threads, an ordinary bolt cutter may be used. For cutting the first thread on a short piece of pipe, insert an iron filler or plug, slightly tapered, to prevent the pipe from collapsing when being gripped by the holding or vise dies. For cutting the threads on the second end, remove the ordinary holding dies and insert the threaded holders

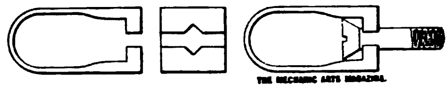


FIG. 3.

shown in Fig. 2; place the threads on the pipe within the threads in the holders, then close up on the pipe firmly, whereupon the work of cutting the threads may be proceeded with as in ordinary cases. To remove the nipple after it is threaded, simply loosen the vise as in bolt cutting, when the nipple can be lifted out with the fingers. In making nipple holders, such as described, care should be taken to make them so as to fit reasonably close in the vise of the carriage, and the threads should be cut in a lathe, so as to have them true, and the alinement to correspond with that of the shank of the holder.

Another troublesome thing to make in the average shop is countersunk bolts of various sizes in short lengths. Trouble arises from the fact that the thin edges of the countersunk head will not admit of being held in the vise of the bolt cutter without being damaged. In order to cut threads on bolts of this kind, a holder such as shown in Fig. 3 has been used with excellent results. It is shown with a square-shaped face, but can be made with a round face just as well for use with machines having close clearances between cutter head and vise of carriage. It also has the advantage of being capable of holding bolts of different sizes.

WEIGHING A LIGHT ARTICLE ON LARGE PLATFORM SCALES.

T. H. Reardon, North Adams, Mass.

PLACE THE article on the weight hanger (all weights being removed and the sliding weight at zero), put enough material on the platform to make the scales balance, remove the article from the hanger, ascertain what weight you have on the platform, and divide it by the ratio of platform load to hanger load, which in Fairbanks scales is usually 100 to 1 or 1,000 to 1; i. e., 1 pound on the hanger will balance either 100 or 1,000 pounds on the platform. The weights of the scale weights will be found in raised letters on the weights.

As an example, suppose we wish to weigh a letter on a railroad freight scales on which a 1-pound weight on the hanger equals 1,000 pounds on the platform. Place the letter on the hanger and a load on the platform that will just balance it. If the load on the platform weighs 50 pounds, then the weight of the letter is $\frac{50}{1,000} = .05$ pound $= .05 \times 16 = .8$ ounce $= .05 \times 7,000 = 350$ grains. I have used this scheme for over ten years, and while it may not adapt itself to the refinements of laboratory work, it is very handy at times.

SUBSTITUTE FOR THUMBTACKS; BINDING INSTRUCTION PAPERS.

W. H. W., Toledo, Ohio.

THE NOTE under Good Schemes in the June, 1899, number of THE MECHANIC ARTS MAGAZINE, about the use of copper tacks instead of thumbtacks to hold paper to the drawing board, suggested to me to send you a description of a convenient little tool I have used for years. Instead of copper tacks or fastening the paper I use the ordinary 1-ounce iron tacks. The tool dresser in the shop made me a hammer out of $\frac{3}{8}$-round tool steel, 6 inches long, by simply turning over one end L-shaped to form the head and grinding the other to a flat point like a cold chisel. This hammer I tempered and polished and then magnetized at the shop dynamo. I keep the tacks in a hole in my inkstand, and when I wish to fasten down a sheet of paper, I put the point of the hammer in it and gather up a lot of the tacks, which I then shake off on the paper. They are then easily picked up by the magnetized head and driven into the board. The tacks can be taken out of the board with the flat end of the hammer, to which they cling, and from which they can be brushed into the holder.

I found, in using The International Correspondence Schools Instruction Papers so much at the office, that they were getting soiled very rapidly. In order to have the bound volumes in good condition for my library, I decided to bind the pamphlets and use them for reference. I bind them by gluing on a piece of blueprint cloth, which has been exposed and washed, the same as if under a tracing, large enough to form the sides and back. I also bind in a few blank leaves for an index, which I subdivide into the letters of the alphabet. But, instead of indexing each book at once, which would take a great deal of time, I wait until I have occasion to look up any subject, and then index it. I thus have two sets of bound and indexed volumes.

BENCH APPLIANCE.

W. E. W., St. John, N. B.

IN THE two accompanying figures is shown an attachment to the ordinary carpenter's bench that is a great convenience to the workman, although I do not know that the scheme is a new one. The device is for the purpose of holding securely any width and thickness of stock in the bench vise while it is being worked up.

On the side of the bench at c, Fig. 2, is a

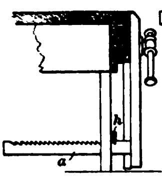


FIG. 1.

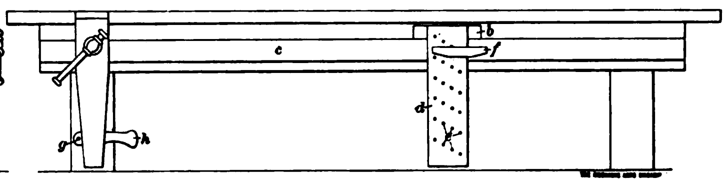


FIG. 2.

wooden guide extending the full length of the bench; its top is plowed with a groove, in which slides the tongue of the carrier b, while attached to b is a face board d, 6 inches wide, and extending nearly to the floor. The face board is pierced with 24 holes, as shown at e, into which may be fitted a dowel on the back of the slide rest f, so that the rest may be secured at various heights. The bottom slide of the bench vise, as shown at a, Fig. 1, is notched on top, and a pawl h is pivoted at g, so that it can be raised with the foot and adjusted to any desired notch in the slide.

In working up stock, it is only necessary to slide the carrier b down from the vise as far as required by the length of the plank, and adjust the rest f according to the stock's width; the pawl h is then forced into the notch that is made to correspond with the thickness of the material being worked, and in this manner it is securely held between the vise jaws without further attention from the workman.

TRADE NOTES

THE SCHOOL OF ILLUSTRATION.

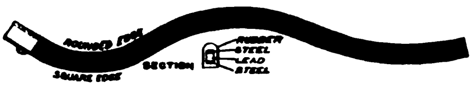
THE SCHOOL OF ILLUSTRATION, 26 E. Van Buren Street, Chicago, Ill., sends us a circular regarding instruction in newspaper illustration, composition, and higher illustration, decorative design, life drawing, caricature, perspective, pen and ink, and portraiture. A feature of the school is the mechanical department, which is fully equipped with all the appliances for making cuts, and for silver print, Ross paper, and chalk-plate work.

F. W. EMERSON MANUFACTURING CO.

DRAFTING-ROOM FURNITURE, a handsome 48-page catalogue, issued by F. W. Emerson Manufacturing Company, Rochester, N. Y., describes and illustrates the drafting tables, blueprint frames, filing cabinets, and other appliances for the drafting room which they manufacture. Their drafting table possesses many excellent features. The pamphlet will be sent on application.

ADJUSTABLE CURVE RULER.

THE ADJUSTABLE curve ruler, shown in the accompanying illustration, is a tool that is fully appreciated by those that use it, and deserves to be known to all draftsmen that have not seen and tried it. Although not a new tool, there are many, particularly



among students, that are not familiar with it; for that reason the following description is given of one of the simplest and cheapest forms.

The ruler comprises a long, narrow casing of flexible rubber, with a square hole through its center; one side has a square ruling edge, the other has a rounded edge, to be used when inking. Through the center of the tool is a strip of drawn lead, square in cross-section; the two opposite sides of the lead, next the ruling edges, are flanked with thin ribbons of tempered steel, and the several parts are clamped together at one end in the ferrule, as shown, allowing them to slide upon one another when the ruler is bent.

The manner of using is to bend the ruler to the shape of any curve it is desired to draw, and use a pen or pencil along its edge. The lead is so proportioned to the other parts that the ruler will remain as it is bent, the lead holding it against the pull of the steel ribbons, which incline to straighten themselves. This gives nice, clean curves that would otherwise be impossible. The ribbons also serve to hold the curves in one plane. The inventor, Mr. F. W. Davenport, Providence, R. I., manufactures several other styles of this ruler, some of which are made entirely of metal, and vary in length from 7 inches to as many feet.

A UNIQUE CATALOGUE.

WE HAVE received from The Cleveland Twist Drill Co., Cleveland, Ohio, a catalogue of drills, reamers, milling cutters, and other articles manufactured by this company. In addition to the description and price list, the catalogue contains more than 300 pages of information useful to engineers, including a table of logarithms and a table of areas and circumferences of circles. The information on mensuration, mechanics, electricity, etc. is well written. A feature that will be appreciated by mechanics is a section of 10 pages, explaining, in an exceedingly clear and simple manner, the use of letters in formulas and the use of formulas themselves. In short, the catalogue will be found in most respects equal to the more pretentious pocketbooks, and will doubtless be appreciated by the engineering profession generally.

BOOK NOTICE.

WE HAVE received from the publishers, Laird & Lee, Chicago, Ill., "The Heart of a Boy," by Edmondo de Amicis, translated from the 224th Italian edition by Prof. G. Mantellini. We can thoroughly recommend this book. It is entirely free from the goody-goody style peculiar to children's books. It is a boy's diary, rewritten by his father, who has preserved the boy's style and thoughts. It is very handsomely bound, contains 32 full-page half-tones, and 26 text illustrations. The price is $1.25.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* THE MECHANIC ARTS MAGAZINE, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*
2. *Only questions of general interest to our readers will be answered.*
3. *No questions will be answered by mail.*
4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*
5. *The names and full addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*
6. *Reference to inquiries previously answered should give date of issue and number of question.*
7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(239) (*a*) Kindly describe a practical and correct method of making a projection for a drawing of a map of the United States, explaining how the length of a degree on a given parallel is calculated; size of sheet, 20 in. × 24 in. (*b*) Do you know of a reliable book on above subject? (*c*) Explain a correct method of projecting hemisphere, showing how to draw the meridians. G. F. C., De Soto, Mo.

ANS.—(*a*) Of the different methods of projection used in the drawing of maps of extensive territories, the method of *polyconic* projection is one of the best. It is the one adopted by the United States Coast and Geodetic Survey. The principle is as follows: The section to be mapped is divided into zones by parallels of latitude. Each parallel, being a circle, is considered as the base of a cone with its vertex on the polar axis of the earth and tangent to the terrestrial spheroid along the parallel in question. The map is constructed by developing the bases of all these cones into circular arcs whose centers all lie in the same line. Thus, let $abhg$, Fig. 1, be the ordinary projection of an area to be mapped, which, for convenience, we will suppose to be bounded by the two parallels of latitude ab and gh. The point C is the center, and the line NS the polar axis, of the earth, P and P' being the poles. Taking the parallel ef, $e v_3 f$ is a cone tangent to the spheroid along the circle ef. Take now an indefinite line $N'S'$, Fig. 2, to represent the central meridian, and, starting from any convenient point *1*, lay off along the line degrees and fractions of a degree, as shown. The lengths of these divisions vary according to latitude, and are given in special tables constructed for this purpose. If no tables are at hand, the length s of one degree

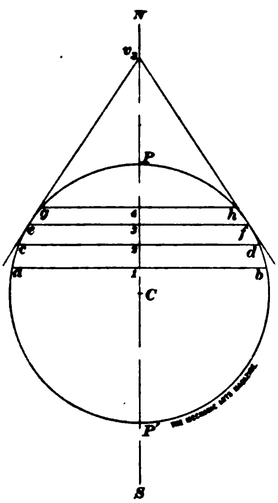

FIG. 1.

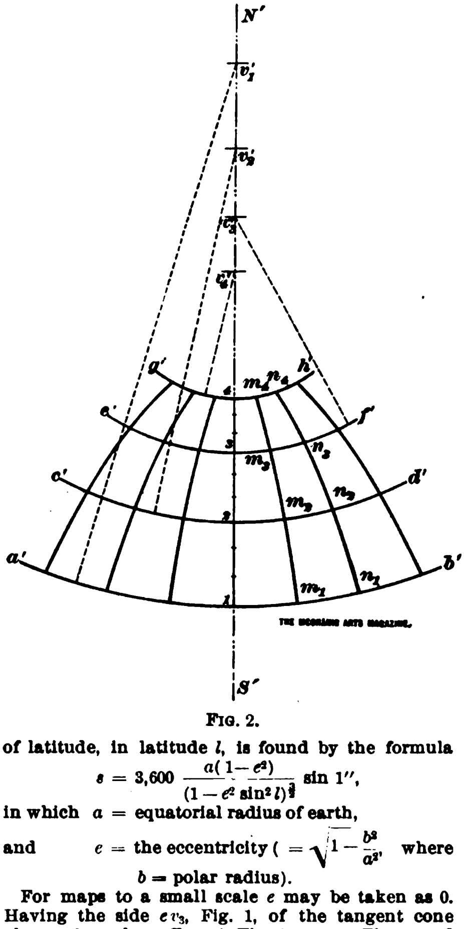

FIG. 2.

of latitude, in latitude l, is found by the formula

$$s = 3{,}600\,\frac{a(1-e^2)}{(1-e^2\sin^2 l)^{\frac{3}{2}}}\sin 1'',$$

in which a = equatorial radius of earth,

and e = the eccentricity ($=\sqrt{1-\frac{b^2}{a^2}}$, where b = polar radius).

For maps to a small scale e may be taken as 0. Having the side $e v_3$, Fig. 1, of the tangent cone along ef, we lay off 3-v_3', Fig. 2, $= e v_3$, Fig. 1, and with 3-v_3' as a radius and v_3' as a center, describe the arc $e'f'$, which is the development of ef. Similarly for other parallels. We now divide each developed parallel into degrees of longitude or fractions thereof, as shown at $m_4 n_4$, $m_1 n_1$, etc., and through corresponding points of division draw the meridians $m_1 m_4$, $n_1 n_4$, etc. Where no tables are at hand, the following formulas are necessary:

$$\text{Side of tangent cone} = e v_3 = 3 - v_3' = \frac{a \cot l}{\sqrt{1-e^2\sin^2 l}}.$$

$$\text{Length of } 1^\circ \text{ of longitude} = 3{,}600\,\frac{a\cos l}{\sqrt{1-e^2\sin^2 l}}\sin 1''.$$

It should be carefully noted that the divisions 3-m_3, $m_3 n_3$, etc. are degrees (or fractions of degrees) of *longitude*, and that the angles corresponding to

them have not their common vertex at v_1'. (*b*) The principles and methods of map projection are found in good books on descriptive geometry (as Warren's) and on surveying (as Johnson's). Tables and data for the application of those principles and methods may be obtained by writing to the U. S. Coast and Geodetic Survey, Washington, D. C. A valuable collection of tables is found in Appendix No. 6 to the Government Report for 1884-85, under the title, "Tables for Projection of Maps on a Polyconic Development of the Clark Spheroid." (*c*) For the projection of the whole sphere or of a hemisphere, the ordinary method of descriptive geometry and projection drawing may be used. This kind of projection is called *orthogonal*. In projecting the whole sphere or half of it, it is customary to make the projection either on the plane of the equator or on the plane of a meridian. Except for very accurate work and maps on an unusually large scale, the earth may be projected as if it were a perfect sphere. We shall show how to project a hemisphere both on the plane of the equator and on the plane of a meridian. (1) Let $NESQ$, Fig. 3, be the principal meridian (say the meridian of Washington), ERQ the equator, and NRS any other meridian (in this case in longitude 60°, so that angle $ECR = 60°$). This figure is a perspective view used for the purposes of explanation. To project the northern hemisphere $EMQN$ on the plane of the equator, draw a circle to represent the equator, as shown in Fig. 4. Since the planes of all meridians are perpendicular to the plane of the equator and pass through the center C, Fig. 3, they will be projected in radial lines, as shown in Fig. 4. All parallels of latitude are projected in true size as circles, since their planes are

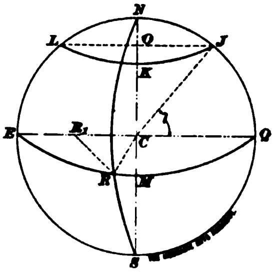

FIG. 3.

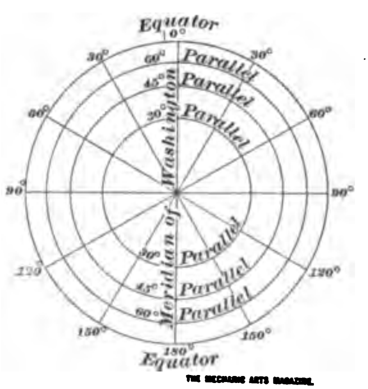

FIG. 4.

parallel to the plane of projection. The radius r of any parallel, as LKJ, Fig. 3, in latitude l, is easily calculated by the formula $r = OJ = CJ \sin NCJ = a \cos l$, where a = mean radius of earth; or it may be constructed by drawing a right triangle whose hypotenuse is a and one of whose acute angles is l; the side adjacent to l (CJO in Fig. 3) will be the required radius. (2) Let it be required to project the hemisphere $NESQM$, Fig. 3, on the plane of the meridian $NESQ$. Draw the circle $N'E'S'Q'$, Fig. 5, to represent this meridian. All circles of latitude will be projected into straight lines, since their planes are perpendicular to the polar axis, and, therefore, to all meridians. Thus, $E'Q'$ is the projection of the equator, and $L'J'$ is the projection of the parallel LKJ, Fig. 3. The distance $C'O' = CO$, Fig. 3, is equal to $a \sin l$, and may be either calculated or constructed as the radius r in the preceding case. Any meridian NRS, Fig. 3, is projected into a semiellipse $N'R_1'S'$, Fig. 5, whose major axis is $N'S'$, and whose minor axis, $C'R_1'$, is found as follows: The minor axis being the projection of CR, Fig. 3, on the plane of the principal meridian, it is equal to the distance CR_1 from C to the foot of the perpendicular RR_1 from R on that plane; and we have $CR_1 = CR \cos RCR_1 = a \cos m$, where m is the longitude of the meridian NRS. In this way $C'R_1'$ in Fig. 5 (= CR_1 of Fig. 3) is calculated. To find it by construction, lay off the arc $E'R_2' = m$ (in this case 60°), and project R_2' up to $E'Q'$, as shown. Other meridians are projected in exactly the same way.

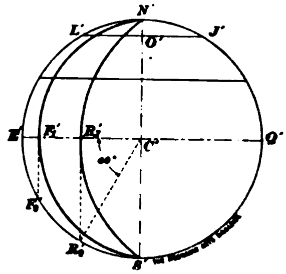

FIG. 5.

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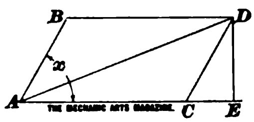
(240) (*a*) Please define for me the following terms: Moment of a force, moment of inertia, radius of gyration. (*b*) Todhunter's "Mechanics" gives the following formula for finding the parallelogram of forces: Let AB and AC represent two forces acting at an angle x; then, if AB = force P, AC = force Q, and AD = force R,



$$AD^2 = \overline{AC}^2 + \overline{AB}^2 + 2AC \times AB \cos x = R^2 = P^2 + Q^2 + 2PQ\cos x.$$

Is this formula correct? (*c*) Using the same diagram, is the following correct?

$$\overline{AD}^2 = \overline{AC}^2 + 2AC\cos x + \cos^2 x + \sin^2 x \qquad (1)$$

$$\overline{CD}^2 = \cos^2 x + \sin^2 x. \qquad (2)$$

Then, substituting (2) in (1),

$$\overline{AD}^2 = \overline{AC}^2 + 2AC\cos x + \overline{CD}^2 = R^2 = Q^2 + P^2 + 2Q\cos x.$$

I know that sines and cosines are really *ratios*, but I think I am right in thus representing them by *lines*.

H. M. K., McKee, N. C.

ANS.—(*a*) It is impossible to give definitions of these terms that are intelligible to any person that has not a considerable knowledge of elementary mathematics and mechanics; and it is a waste of your time and energy to endeavor to understand the terms "moment of inertia" and "radius of gyration" before you comprehend the parallelogram of forces. From your difficulty with the parallelogram of forces it is evident that your knowledge of trigonometry is insufficient to enable you to read profitably such a book as Todhunter's "Mechanics"; to do so you require to know an amount of trigonometry equivalent to Todhunter's "Trigonometry for Beginners." Both of these are good books, and it is not impossible for you to read them without a teacher though the books were written for students that

have the benefit of a teacher. You will find the terms you mention defined and explained in Todhunter's "Mechanics." The simplest definitions of these terms are as follows: The *moment of a force with respect to a point* is the product obtained by multiplying the force by the length of the perpendicular drawn from the point to the line of action of the force. To define moment of inertia and radius of gyration, conceive the whole mass of a body divided into a very great number of very small parts or masses. Then the *moment of inertia of the body with respect to any line* is equal to the sum of all the products obtained by multiplying each of the small masses by the square of its perpendicular distance from the line. Let M denote whole mass of the body; m_1, m_2, m_3, m_4, etc. the masses of the small parts; d_1, d_2, d_3, d_4, etc. the perpendicular distances of m_1, m_2, m_3, m_4, etc. from the line; and let I denote the moment of inertia. Then the definition of moment of inertia which has just been given is expressed by the equation

$$I = m_1\,d_1^2 + m_2\,d_2^2 + m_3\,d_3^2 + m_4\,d_4^2 + \text{etc.}$$

The *radius of gyration of the body with respect to a line* is equal to the square root of the quotient obtained by dividing the moment of inertia of the body with respect to that line by the mass of the body. If K denotes the radius of gyration, this definition of the radius of gyration is expressed by the equation

$$K = \sqrt{\frac{I}{M}}.$$

From which we obtain

$$K^2 = \frac{I}{M},$$

or

$$I = M\,K^2.$$

(*b*) The formula given by Todhunter is correct; this formula is proved as follows: Draw $D\,E$ perpendicular to $A\,C$ produced. By geometry we have,

$$\overline{A\,D}^2 = \overline{A\,C}^2 + \overline{C\,D}^2 + 2\,A\,C \times C\,E.$$

But, $C\,D = A\,B$; and therefore

$$\overline{A\,D}^2 = \overline{A\,C}^2 + \overline{A\,B}^2 + 2\,A\,C \times C\,E. \quad (3)$$

The angle $E\,C\,D$ is equal to x, and by the definition of the cosine of an angle, we have

$$\cos E\,C\,D = \cos x = \frac{C\,E}{C\,D}. \qquad (4)$$

Therefore,

$$C\,E = C\,D \cos x = A\,B \cos x.$$

Putting $A\,B \cos x$ for $C\,E$ in (3), we get

$$\overline{A\,D}^2 = \overline{A\,C}^2 + \overline{A\,B}^2 + 2\,A\,C \times A\,B \cos x;$$

or,

$$R^2 = P^2 + Q^2 + 2\,P\,Q \cos x.$$

Your equations (1) and (2) are not correct if we define the cosine of an angle as a ratio, as in equation (4). To make your equations correct we must define the sine and cosine by equations (5) and (6):

$$\sin E\,C\,D = \sin x = E\,D; \qquad (5)$$

$$\cos E\,C\,D = \cos x = C\,E. \qquad (6)$$

Substituting $\cos x$ for $C\,E$ from (6) in (3), we get

$$\overline{A\,D}^2 = \overline{A\,C}^2 + \overline{A\,B}^2 + 2\,A\,C \cos x.$$

But,

$$\overline{A\,B}^2 = \overline{C\,D}^2 = \overline{C\,E}^2 + = \overline{E\,D}^2 = \cos^2 x + \sin^2 x. \quad (2)$$

Therefore,

$$\overline{A\,D}^2 = \overline{A\,C}^2 + \cos^2 x + \sin^2 x + 2\,A\,C \cos x$$
$$= \overline{A\,C}^2 + 2\,A\,C \cos x + \cos^2 x + \sin^2 x. \quad (1)$$

Accordingly your equations (1) and (2) are correct if the sine and cosine are defined by equations (5) and (6). Formerly the sine and cosine were defined in this way as lines; but these definitions have long since been abandoned because they were found very inconvenient. The cosine of an angle is always now defined as a ratio by means of equation (4).

(241) (*a*) Please tell me what I can mix with orange shellac to produce a smooth, glossy polish. Will the same do for black shellac for patterns? (*b*) With what can I stick lead numbers or leathers on iron patterns? L. A. S., New Bedford, Mass.

ANS.—(*a*) The Scientific American Cyclopedia contains the following: "A varnish has been patented in Germany for foundry patterns, which, it is claimed, dries as soon as put on; it gives the patterns a smooth surface, thus insuring an easy slip out of the mold; it prevents the patterns from warping, shrinking, or swelling, and is quite impervious to moisture. This varnish is prepared in the following manner: 30 pounds shellac, 10 pounds Manila copal, and 10 pounds Zanzibar copal are placed in a vessel, heated externally by steam, and stirred during 4 to 6 hours, after which 150 parts of the finest potato spirits are added, and the whole heated during 4 hours to 87° C. (189° F.). This liquid is dyed by the addition of orange color, and can then be used for painting the patterns." We suppose this varnish can be colored black by the addition of lampblack, without injuring its qualities. (*b*) An experienced patternmaker says that the backs of the letters are coated with shellac, and the letters are then stuck on the pattern, which must be coated with shellac before the varnish dries.

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(242) Kindly show how to determine the diameter of a pipe that will carry 8,000 gallons of water per minute, with a fall of 2 feet per mile. I have worked this problem by means of the formula given in the Mechanics' Pocket Memoranda, and also by Kutter's formula, but the results obtained do not agree. I suppose I have made some mistake in applying the formulas. J. P. S., Stockton, Cal.

ANS.—Calculating the diameter by the formula given in the Mechanics' Pocket Memoranda, we have, remembering that in the formula the discharge is in gallons per second,

$$d = 1.229\sqrt[5]{\frac{l\,Q^2}{h}} = 1.229\sqrt[5]{\frac{5{,}280 \times 8{,}000^2}{2 \times 60^2}} = 42.6 \text{ inches.}$$

This is probably a reliable value for a smooth pipe, when new and in the best of condition. Kutter's formula, as usually written, is not in a convenient form for calculating the diameter of a pipe for a given discharge. A formula that is highly recommended for the case of rough cast-iron pipes, as ordinarily laid, is the following modification of Darcy's formula:

$$D = \sqrt[5]{\frac{Q^4}{h}},$$

in which D = diameter of pipe in feet;
Q = discharge in cubic feet per second;
h = fall per thousand feet of length of the pipe.

Applying this formula to your example, we have

$$D = \sqrt[5]{\frac{8{,}000^2}{7.48^2 \times 60^2} \div \frac{2}{5.28}} = 3.844 \text{ feet} = 46.128 \text{ inches.}$$

The nearest standard size is 48 inches, which is probably the diameter that should be used.

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(243) (*a*) We have a nest of four boilers that feed into a 7-inch pipe which supplies an engine with steam through a 5-inch pipe. We now wish to supply another engine by means of another 5-inch pipe from the same 7-inch pipe. Will the one 7-inch pipe be capable of feeding the two 5-inch? (*b*) If one of the engines were placed at the end of the 7-inch pipe, where should a 5-inch pipe be connected for the other engine, to obtain the best results? J. C., Decatur, Ill.

ANS.—(*a*) The internal area of a standard 7-inch wrought-iron pipe is 38.737 square inches, and the area of a 5-inch pipe is 19.99 square inches; the two 5-inch pipes will therefore have an area of 39.98 square inches, a little more than the one 7-inch. The resistance to flow through the 7-inch pipe would

be less in proportion to its area than through the two smaller pipes, and, if the connections are properly made, the 7-inch pipe should easily supply the two smaller ones. (*b*) Attach the second 5-inch pipe at the point that will give the shortest and most direct connection between the 7-inch pipe and the engine.

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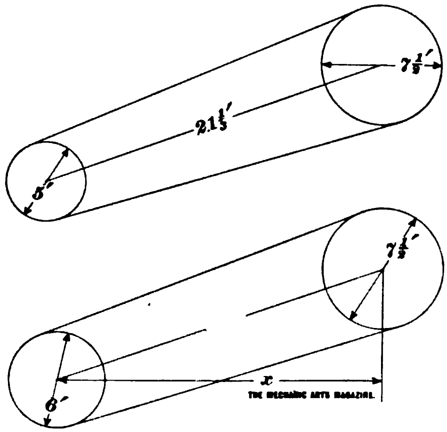
(244) The distance between the centers of two pulleys, 5 and 7½ feet in diameter, is 21⅓ feet. What



is the horizontal distance x when the pulleys are 6 and 7½ feet, the length of belt and vertical distance between centers of 7 feet remaining the same?

A. W. B., Miles Grove, Pa.

ANS.—The length of the belt is, closely enough, equal to half the circumference of one pulley plus half that of the other, plus twice the distance d between centers. Thus,

$$L = \frac{7.5\,\pi}{2} + \frac{5\,\pi}{2} + 2 \times 21.3333;$$

and,

$$L = \frac{7.5\,\pi}{2} + \frac{6\,\pi}{2} + 2 \times d.$$

Putting both expressions equal, we get

$$d = \frac{1}{2}\left(2 \times 21.3333 - \frac{\pi}{2}\right) = 20.5479 \text{ feet.}$$

Furthermore, $x = \sqrt{d^2 - 7^2} = 19.0844$ feet.

***

(245) (*a*) What is the best way of applying asbestos in flour form to a hot-water heater? My idea is to mix it with some liquid and so make a mortar that, when laid on the smooth surface of the heater, will adhere securely. (*b*) I am thinking of putting a water-heating apparatus in a greenhouse, 100 feet long, 20 feet wide, 9 feet high, exposed on two sides, and having ⅓ pitch. How must I arrange the pipes so as to get the most satisfactory results, and what size pipes should be used? I wish to employ a low-pressure system of heating, and to place the heater at one end above the ground.

F. W. R., New London, Ohio.

ANS.—(*a*) It is customary among steam fitters to mix asbestos in cement or mortar by the introduction of water and plenty of "elbow grease." The cement must be thoroughly mixed and made very plastic before it is applied in the ordinary manner with a trowel. To keep it from cracking and falling off a smooth surface, such as the outside of a hot-water heater, we would advise you to encircle the heater with wires or a screen, or something to which the mortar can adhere. (*b*) The proper way to arrange pipes so as to get the most satisfactory results is to place them under the benches and around the exposed walls as much as possible; but if you set the heater above the ground, that is, above the level of your coils, the circulation will be too sluggish for proper results. We advise you to dig a pit and set the heater at least 3 feet below the coils, in the ordinary manner. It is foolish to court trouble by setting the heater higher than the heating coils. Use 4-inch pipe for the coils, if you can afford it.

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(246) I wish to design a stand pipe 8 feet in diameter, 100 feet high. Kindly give the following information regarding it: number of sections of which it should be built, diameter of foundation, material, how arched, class of steel, thickness of each section, general construction and dimensions of the foundation. E. E. R., Moundsville, W. Va.

ANS.—The question is too extensive to be answered in these columns. We must draw the line at furnishing complete plans and specifications for engineering work, not only in justice to our colleagues in the profession, but also because we feel it to be too great a responsibility to place data of this kind in the hands of laymen.

***

(247) I have a steam boiler, 60 inches by 16 feet, furnishing steam at 100 pounds pressure to a 12″ × 36″ Corliss engine and a 9″ × 9″ slide-valve engine. Every week or two the boiler leaks, not all over at once, as it used to, but one side at a time. There is not much scale on the head, and what there is is on the bottom of the tube. What, in your opinion, is the cause of the leaking?

J. A. B. K., San Francisco, Cal.

ANS.—We really cannot say why it should leak on the one side more than on the other. Perhaps the seams and rivets on the other side have been calked without your knowledge. Or you may have been putting in meal, sawdust, or something of the kind to stop the leaking, and the seams have for some reason "taken up" more on the one side than on the other. This is only surmise, but in the absence of all knowledge as to the conditions, trivial and otherwise (and we cannot conjure up every possible contingency), we cannot tell you anything more explicit. As to the reason for the boiler leaking at all, periodically, it may be due to change of feed-water, getting up steam too quickly, blowing out while under steam and thus cooling off suddenly, or, worse still, you perhaps proceed to wash out with cold water before the boiler has cooled down. Or, maybe, intending to clean out the inside, you do not wait for the boiler to cool down gradually, but open the dampers and fire-door and so let the cold air in. This is as bad a practice as you can indulge in.

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(248) The suction pipe of a pump aboard ship is provided with a strainer, which becomes clogged frequently with grass and sea weed. It is located 7 feet below water-line. To clear the strainer, after closing the suction valve, steam is blown into the pipe through a 1¼-inch pipe provided for the purpose. The clearing of the strainer is accompanied by a loud report. Does this indicate danger to the pipe, which is of cast iron, 1¼ inches thick? If so, what would you advise? W. H., Seattle, Wash.

ANS.—The report is caused by the sudden influx of water after the strainer is cleared, intensified by the condensation of steam. This may prove dangerous to the cast-iron pipe. We would use water instead of steam, connecting the 1¼-inch pipe with a tank holding about 20 gallons, located above water level.

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(249) How much power is required to drive a 2″ × 12″ emery wheel at a speed of 5,500 feet per minute? The journals are 1¼ in. × 6 in.

R. H. S., Nebraska City, Neb.

ANS.—The power necessary may be from ½ to 3 horsepower, according to material ground and grain of wheel.

SELF HELP

BRAVERY ESSENTIAL TO SUCCESS.

"NO GREAT deed is done by falterers, who ask for certainty." These ringing words of George Eliot are illustrated by Felltham, who adds: "Irresolution is a worse vice than rashness. He that shoots last may sometimes hit the mark, but he that shoots not at all can never hit it. Irresolution loosens the joints of a state; like an ague, it shakes not this nor that limb, but all the body is at once in a fit. The irresolute man is lifted from one place to another, so hatcheth nothing, but addles all his actions."

Lieutenant Hobson's exploit in connection with the Spanish-American war has scarcely passed from our minds. But, great as it was, it is only one of many acts of heroism on record in naval warfare.

It will interest the present readers if we remind them of the thrilling adventure—one of the most heroic in English history—of a mere lad in the British navy, which occurred nearly two hundred and fifty years ago.

In one of the most hotly-contested battles ever fought between English and Dutch seamen, the masts of Sir John Narborough's flagship were shot away early in the encounter. The admiral at once perceived that his case was hopeless, though his men might fight ever so bravely, unless he could in some way bring round to his assistance the English Reserve, which lay off to the right, some distance away. To signal them was out of the question, of course. There was but one hope, and that was a forlorn hope—if somehow he could get carried to these ships a message conveying the admiral's command, he might get help in time to avert calamity. Yet it was plain that no boat could reach those British vessels with the Dutch ships lying between, and a perfect hail of shot and shell coming down with such fatal violence and frequency. True, a man might swim to those reserve ships and possibly escape the gauntlet of the enemy's fire; but would any seaman undertake it? It was a last resort, but Sir John wrote an order for these vessels to come to his aid, and then asked whether any man would volunteer to take his despatch under the enemy's fire to the neighboring ships. A throng of able-bodied sailors presented themselves, ready to undertake the risk; and among them stood forth, conspicuously, one fearless lad. The admiral looked at him with a look in which pity and admiration were mingled, and said, "My boy, what can you do?" "I can swim, sir; and if I be shot, sir, I can be easier spared than any one else." The boy was both a hero and a patriot. The kind-hearted admiral hesitated for a moment and then handed to the brave lad the paper containing the order on which all hope depended.

The boy placed it between his teeth, holding it desperately fast, and plunged into the water, which was a seething caldron under the hot fire of the Dutch vessels. His comrades cheered him as on he swam, shot falling and shell bursting all around him. At times, in the thick smoke, he was lost sight of, but again for a moment would reappear, still swimming on towards the ships, as though he bore a charmed life. At length he was lost to sight.

The brave admiral and his faithful crew held on with desperate determination, but as no help came, it seemed very certain that the heroic boy had perished in the angry flood. They were just beginning to look on the day as lost, and themselves as lost also, when on their right was heard a sudden and terrific thunder of cannon. The boy had reached the reserve squadron in safety, and delivered his message; and the friendly vessels were bearing down directly on the Dutch with all their artillery. It was but a few hours before the tide of battle turned and swept the Dutch ships away, disabled and defeated. The enemy was fleeing in all directions and the day was won.

The cabin boy deserved a reward, for he had saved his country from defeat, and when the honors and dignities of that terrible day were distributed, he was not passed by. As the sunset fell upon the awful scenes of peril and naval struggle, he was called to the deck of the flagship, to hear the

admiral's words of praise and commendation for his brave deed of daring; and Sir John added what proved prophetic: "I shall live to see you have a flagship of your own."

That boy was Cloudesley Shovel. Not long after, he was made a lieutenant in Her Majesty's navy. Lieutenant Shovel, only twenty-four years old, was sent with a message for the Dey of Tripoli, in 1674, which he delivered as became a British sailor, but he came back with a haughty, insolent, and indefinite answer. In one way his mission was fruitless, but not in another. He had not gone with shut eyes or ears, and on his return to the admiral, gave him so accurate and sagacious account of the fortifications of the enemy and the disposition of the piratical fleet, that he was again sent to the Dey with further despatches, in order to make further observations. This time he returned prepared to give not only a fuller description of the enemy's situation, but to suggest a successful plan of attack. The admiral was so gratified with his sagacity that he entrusted to him the execution of the plan he had proposed.

On the 4th of March, at night, Lieutenant Shovel took command of all the boats of the fleet, filled with combustible material. Under cover of darkness he rowed quietly into the harbor and made straight for the guard ship. This he fired and disabled, and thus prevented its giving orders to the rest, and before the enemy could get ready for action, he fired and blew up vessel after vessel, and then brought back all his boats to his own fleet; and in this brave exploit, so splendidly executed, he had not lost one man!

Promoted now to a captaincy, he was subsequently made "Rear-Admiral of the blue," then "of the red," then "Admiral of the white"—and is known in history as Sir Cloudesley Shovel.

His body is buried in England's great Westminister Abbey. Born in 1650, and wrecked on the rocks of the Scilly Isles in 1707, he died at the age of fifty-seven, universally lamented. But no exploit of his forty years as a British seaman will be so long remembered as his heroic mission in bearing the admiral's message to the reserve fleet in his boyhood.

Train a boy to be brave, and to speak the truth, and you have done your best by him: the rest he must do for himself.—*Gen. Lew Wallace.*

AIM AT THE PRACTICABLE AND POSSIBLE.

IN YOUR career aim at the practicable and the possible. Solidity of character is attained not by doing great deeds alone, but by doing common duties more promptly and faithfully than other men. When you have shown yourself faithful in a little, you will be trusted with much. Always measure your strength before you take hold of any enterprise; but when once you have entered upon it, so bear yourself that your fidelity cannot be questioned. The habit of fidelity will give you confidence in yourself, and give others confidence in you. The world never pardons the man who is unfaithful to his trust.

Above all, remember that character is a word of great comprehension. To be real, it must be enduring as eternity. Men seek honor, power, fame, and wealth as modes of well being. But we all know that all of these may be attained and still leave the heart "dry as summer dust," and the soul burning with thirst for the "water of life." All these are but forms of power. In themselves they cannot satisfy the longings of the soul. The law that binds moral beings is self-sacrifice and devotion to duty. Power of any sort, made into an instrument of selfishness, becomes a weariness and weakness to the possessor. Power used to curse, and not to bless, reacts in unutterable remorse. He who seeks to attain permanent well being, must take the moral law as a factor into his thought and striving.

FIRING AT ONE SPOT.

MANY years ago an old castle, very strongly fortified, was taken by a single gun. The attacking party had only the one gun, and it seemed hopeless to try to take the castle; but one soldier said, "I can show you how you can take the castle." He pointed the cannon at one spot and fired, and went on all day, never moving the cannon. Each ball knocked a few stones from the wall. The same thing was repeated the next day, and the next. By and by the stones began to fall away, and by steadily working the gun he made a hole big enough for the army to walk through, and the castle was taken.

When any task looks at first sight as impossible as the taking of this old castle, look the ground over, start aright, and don't give up until the battle is won. Remember that "perseverance conquers all things."

JEROME HALL RAYMOND.

THE NEWSBOY WHO BECAME PRESIDENT OF WEST VIRGINIA UNIVERSITY.

THE University of West Virginia has a faculty of fifty-six professors and instructors, and an enrollment of nearly one thousand students. It has, besides, in the person of Jerome Hall Raymond, Ph. D., the second youngest president of any university in the country, one of the most able, tactful, and remarkable men among the younger generation of America's men of intellectual prominence and educational usefulness.

Two years ago, at the surprisingly early age of twenty-nine, Mr. Raymond was selected to fill the Presidency of the West Virginia University; and the brilliant yet substantial successes he has since achieved fully justify the wisdom of the choice then made. His course as President of the university has been characterized by great ability and aggressiveness, and under his firm, as well as far-seeing rule, the institution has grown and expanded to a remarkable degree. He has introduced the continuous-session plan, by which all departments of the university are is session throughout the year; he has established instruction by correspondence; founded a School of Music; added Departments of Drawing and Painting, and of Domestic Science, besides greatly strengthening other departments of the university. His sound judgment and originality as an administrator have attracted the favorable notice of the educational world, usually so cautious, and often, we may say it, so fastidious.

That gifted and justly beloved woman, Frances E. Willard, tells the story of Jerome Hall Raymond's early life struggle — a struggle illustrative of self-knowledge, self-respect, and self-control.

This story also recalls Ruskin's famous saying: "There is not an hour of youth but is trembling with opportunities, not a moment of which, once past, the appointed work can ever be done again, or the neglected blow struck on the cold iron."

Miss Willard tells us that young Raymond was a little fellow, perhaps seven, with a fine, well-knit boyish figure and winsome face. He lived with his mother and older sister in two rooms in Chicago, in circumstances threatening to soon become trying from need, for the mother was a soldier's widow, living on the scant resources of a modest pension. "Give me a penny," said young Raymond one day to his sister, "Give me a penny." So earnestly and so repeatedly did the boy prefer the request that his sister at length gave him the penny. With that penny he bought an evening paper and hurrying along the street kept on saying: "Who will give me two cents for this paper?" His handsome figure and winning way soon found him a purchaser, and started him on a career of success as a newsboy. After much difficulty he succeeded in obtaining a place in front of the Sherman House, where good fortune blessed his tact, persistence, and good conduct. None of the evil ways of the street contaminated him, and he regularly brought home all he earned to the mother and sister he loved so well. Growing older, he went to evening school, keeping up with boys of more leisure and better opportunities. He also acquired such an accurate knowledge of bookkeeping and stenography that at the age of fourteen he was perhaps the most thorough master, for his years, of these valuable acquirements to be found in the country.

For nearly a year he was secretary to George M. Pullman, the palace-car capitalist; and in that trusted, as well as exacting, position won golden opinions.

At eighteen he went with his mother and sister to Evanston, Ill., and there took the

university course, supporting his loved ones in comfort in a house purchased from his savings.

For three years he was Miss Willard's stenographer, and of his work that noble woman writes: "He helped me as perhaps hardly any other has ever done, for his work was at once so rapid and so accurate that I did not have to look it over, and I was able to put several days' efforts into one."

We next find him accompanying Bishop J. M. Thorburn as secretary and companion to India, where young Raymond made himself master of Sanskrit. Returning with Bishop Thorburn on his trip around the world, Mr. Raymond studied at the John Hopkins University, and at the University of Chicago, taking in the latter institution the degree of Doctor of Philosophy. While preparing for this degree he was in charge of the Class Study Department of the University of Chicago, and in two years increased its members from two hundred and fifty to more than two thousand.

He became, not long after, Head Professor of Sociology in the University of Wisconsin, whence he was called to the Presidency of the University of West Virginia. Twenty years of untiring and unselfish work have placed him in this proud position of influence and usefulness. He was loyal to mother and sister and to home, and that loyalty guarded him against the temptations that beset so many young men and blast so many promising lives. He has been persistent. No matter what opposition he met, or discouragement overtook him, he went ahead. Drudgery could not weary him.

After having completed his university course, Mr. Raymond married Miss Hunt, who, by a singular coincidence, had, some time before, taken the prize of oratory over the bright young student so soon to be her husband.

Dr. Raymond's uninterrupted successes are due to that self-reliance which is the mainspring of every lasting triumph.

O small beginnings, ye are great and strong,
Based on a faithful heart and weariless brain!
Ye build the future fair, ye conquer wrong,
Ye earn the crown, and wear it not in vain.

"The key to success, in any department of life, is self-denial. Idleness, laziness, wastefulness, come from lack of it; while industry, promptitude, economy, thrift, and a successful career are the result of it."—*Neal Dow.*

HARMONY OF MIND AND BODY.

IF A wagon is overloaded, or left out of doors, exposed to wind and rain; if the axles are allowed to get dry and the fellies to shrink, it will not last a quarter as long as if it had been properly cared for and protected. If the farmer does not keep his harnesses sheltered, cleaned, and oiled, they become brittle and break. A piece of machinery needs to be carefully oiled and dusted. Everything we use must be taken care of if it is to be serviceable and enduring.

So with that intricate machine not made with hands—the body. If it is neglected or abused, however ignorantly, it will rust and fall away. The man who might have lived a hundred years dies at forty, because he has sped the wheels of life too fast, clogged them with refuse, or ruined his body by exposure and excess.

If one owns an animal, he does not forget that there are laws of hygiene to be observed in making it most efficient. His thoroughbred horse or his new thrashing machine receives the benefit of all the information he can obtain as to its proper care and management. If he builds a house, he makes it a study to secure the best and most durable materials, and when it is finished, he does not begin to bang the doors and whittle the woodwork. We recognize and observe the laws of hygiene when what we call our "property" is concerned. But whether it is that we fail to see in our bodies the invaluable and costly machine that has no duplicate, the most expensive house we possess, or whether we have grown so obtuse that we cannot appreciate any investment less gross and material than lumber and iron, certain it is that the majority of people utterly ignore the laws relating to the welfare and preservation of their own bodies. We live almost as if there were no such laws. We even make light of rules of health.

Dr. W. G. Anderson declares: "A one-sided education is not perfect, and that scheme for 'unfolding a human being' that leaves out the physical is one-sided. Instead of strengthening the foundation of education, or developing the material upon which we are to build, we vary, modify, change, and elaborate the superstructure, and then wonder why we make so little progress. I do not hesitate to place myself on record as prophesying that the living of the completest life that it is possible to live will be realized when the foundation of education is strengthened; when the belief prevails that the

groundwork is just as important, though neither so beautiful nor impressive, as the building itself."

Select food rich in material to build up the body you live in. Brain, bone, and muscle are not made out of layer cake and floating island.

Dress in warm, light clothing, so that the circulation may be even over the whole body. If you wish sound lungs, dress so that you can breathe deeply, and if you wish a clear head, keep your feet warm and dry.

Eat moderately, sleep moderately, and hurry up moderately. Be moderate in everything.

Don't fret and worry about your own affairs or your neighbors'. A fretful, irritable temper can break down the constitution sooner than hard work.

Eat, sleep, and rest at regular hours. The millions of brain cells and delicate nerves are adjusted to a certain rhythm which results in harmonious living and thinking. Destroy this rhythm by irregular hours and the whole nervous system is thrown into a jangle, the brain confused, the digestion disturbed, and presently we hear of a breakdown.

Every man who would be well, needs every day to take plenty of healthy exercise which will send the blood and nerve currents thrilling and tingling to the very tips of the toes and fingers, giving fresh life to the whole body.

Genial, unselfish cheerfulness, which warms a man in his inmost life, helps him to be strong and well, not only in body, but in mind.

To bend the shoulders and hollow the chest when walking, not only injures the lungs, but gives one a look of weariness and depression. To bend forward, with the legs lagging behind, is not only an ungraceful, but a very tiresome way of walking, as all the strain comes on the back.

Hold the chest and head up with strength and courage, and the chin down with firmness; put the foot down lightly and evenly; bend the little spring in the instep which makes the step easy and flexible, and then walk from the hips, not from the knees. Walking is a delightful and fascinating exercise when practiced as an accomplishment.

Remember the old saying: "A healthful soul in a healthful body." Preserve the harmony of mind and body.

"Only live fish swim up stream."

THE MAN WITH A PROGRAM.

THE man who succeeds has a program; fixing his course, he adheres to it. He lays his plans and executes them. He goes straight to the goal, not pushed to this side or that every time a difficulty is thrust in his way. If he cannot go over, he goes through difficulties.

Those who make great failures in life are the aimless, the purposeless, the indifferent, the blundering, the shiftless. No purpose is there running through the work of such men, unifying their efforts and imparting significance to their lives. The man with a distinct aim, an all-governing purpose, excites admiration because he is lifted above the meanness, the cheapness, and the pettiness which darken, hamper, and narrow small and empty lives. There is a moral grandeur in everything such a man does, because the nobility of his aim exalts even the commonest actions. The man with one talent concentrating the powers of that one talent on some one definite, unwavering aim, accomplishes more than the ten-talent man who divides his energies and scatters his powers.

Charles Kingsley very beautifully says: "Let any one set his heart to do what is right, and ere long his brow is stamped with all that goes to make up heroic expression." To which Phillips Brooks adds: "No man can live a half life when he has genuinely learned that it is a half life. The other half, the higher half, must haunt him."

One man with a program and a purpose in life was James G. Blaine. At an early period in life he set before himself the aim to be another Henry Clay and a greater than Henry Clay.

In his graduation address, delivered in September, 1847, when he was eighteen years of age, young Blaine, speaking of the "Duty of an Educated American," said: "The sphere of labor for the educated American is continuously enlarging. But recently we added the vast dominion of the Lone Star Republic to our glorious Union. The war to which that act gave rise is now in victorious progress, and will not end without another great accession to our territory, possibly carrying our flag beyond the great American Desert to the shores of the Pacific sea. Where our armies march, population follows; and the full duty for the scholar is to be continental in extent and as varied as the domains of a progressive civilization."

After graduation Blaine first found employment in a military school at Blue Lick

Springs, Ky. He subsequently taught in the Philadelphia Blind Asylum, but from 1854 onward, was wholly identified with Maine. Becoming part owner and editor-in-chief of the *Kennebec Journal*, he entered on a career of active politics and journalism. His rise was rapid, for his ability was as unmeasured as his industry was unlimited. He attended the first national Republican convention in 1856 and took active part in the campaign which followed. In 1858 he was for the first time elected to a position of public trust—a seat in the Assembly of the Maine Legislature. Here he devoted himself to a careful and exhaustive study of parliamentary usage and debate. An assiduous student of all public questions, he made himself master of the methods of procedure in legislative bodies, not by power of intuition, but by diligent study of rules, precedents, and historical examples. Soon did he become such a recognized authority on parliamentary practice that two years later he became Speaker of the House of Representatives of the State of Maine.

Blaine was elected in 1862 to the Thirty-eighth Congress, succeeding Anson P. Morrill. His very first speech in Congress, delivered in 1863, in advocacy of the assumption, by the National Government, of all the debts incurred by the states in the prosecution of the Civil War, gave him a national standing. He became a leader in Congress, one whose utterances were eagerly read and whose opinions were readily followed. On the 4th of March, 1869, Mr. Blaine was elected Speaker of the National House of Representatives. As Speaker he was alert, thoroughly versed in parliamentary usage, and in the rules, regulations, and precedents of his high office. Impartial, quick, self-poised, he was probably, in all respects, the best equipped parliamentarian who ever filled that historic chair, with one exception alone, his great exemplar, Henry Clay, who still holds the reputation of having been the best Speaker ever known to the House of Representatives.

Speaker Blaine spent more hours in the chair than any of his predecessors, and was hardly ever absent from his post. Always courteous and fair, never losing his head, he alone, when the most exciting scenes of parliamentary confusion prevailed on the floor of the House, remained immovable, composed, and intently observant of every motion of the tumultuous sea enclosed within the Capitol. There is no doubt that Mr. Blaine sought to make the Speakership the stepping stone to the Presidency. In this purpose he, like the great Commoner of the West, Henry Clay, finally failed. His life was, however, like that of Clay, of inestimable value to his fellow men, and an indescribable honor to America and to American citizenship—for, taken as a whole, it was a life of unremitting toil and of extraordinary triumph.

THE QUALITY OF COURAGE.

Fancy the world a hill, lad;
Look where the millions stop—
You'll find a crowd at the base, lad;
There's always room at the top.

A true man, though gentle, is never fearful. Of high courage, he not only asserts himself, and proclaims his own purposes, but helps his neighbor at the greatest risk. The line of heroes is not yet extinct. There are many of all classes, who will venture their lives to rescue drowning men or women; who will snatch the helpless from burning flames. The history of modern society incontestably proves that mankind is still blessed with such heroic benefactors. There are still also founders of charities for the sick, the destitute, and the abandoned. There are still men ready to sacrifice themselves in peace and war for the weal of others, in the alleviation of distress and the removal of danger to life and limb.

When the venerable Marshall De Mouchy was, during the first French Revolution, led to the scaffold for protecting the devoted victims of popular fury, a voice was heard from the crowd, saying, "Courage, Mouchy! Courage, Mouchy!" The hero, turning from those by his side, uttered these memorable words: "When I was 60 years of age, I mounted the breaches for my King, and now that I am 84, I shall not want courage to mount the scaffold for my God."

Courage even in minor things is useful. If one cannot be a hero, he may always be a man. Courage faces, and eventually overcomes, all the difficulties of life. Courage enables us to adhere to good, and avoid bad, resolutions; to pay our debts and not to live upon the means of others; to speak freely, but to be silent where others might be injured; to examine ourselves and to confess ignorance; to admit that we have been in the wrong; to detect faults and amend our conduct to the best of our ability.

Moral courage can do all these things, though at first sight they may seem full of difficulty.

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I tried for two years to learn from textbooks, but I learned more in three months' time, after I enrolled in The International Correspondence Schools, than I did in the whole two years. It has seemed to me as if it was a pleasure to you to give me any special instruction I have needed. I have enough plumbing work now in sight to repay me for my Scholarship, and have had a raise in wages from $50.00 to $65.00 a month.—*J. B. Crosby, Tinner, Savannah, Mo.*

LARGER SALARY AS CHIEF ENGINEER.

For some time previous to enrolling in the Schools I had been reading everything I could get pertaining to mechanical and electrical engineering, but found that to receive any benefit from the better class of books, I needed a better education in mathematics. I read of the Correspondence Schools, but hesitated about trying the method of instruction, as there was no one in Topeka, at that time (1894), who knew anything about them. But finally I enrolled, and was very sorry afterwards that I hesitated, after seeing how beneficial it was in my work.

When I enrolled I was second engineer. About one year afterwards I was promoted to the position of chief engineer, at a much larger salary.—*J. L. Chase, Chief Engineer, Topeka, Kan.*

COMMANDS A LARGER SALARY.

It is now two years since I enrolled in the Plumbing, Heating, and Ventilation Course of The International Correspondence Schools. I have found it very beneficial to me in my business; I am now able to command a larger salary than ever before. I am pleased with the way in which you conduct your Schools, and would recommend them to all. Every mechanic should enroll and be convinced of the sterling worth of your institution.—*Linn H. Hall, Plumber, Mount Morris, N. Y.*

IS NOW PRACTICING ARCHITECTURE.

After vainly trying to secure an education from textbooks, I enrolled in the Complete Architectural Course of The International Correspondence Schools. I cannot praise the Schools too highly for their efforts to aid ambitious students to succeed. They have notified me of several good openings, all better than I had ever hoped to hold, before studying in my Course. I now have an architect's office in this city, with good prospects ahead. —*Edward A. Strong, Architect, Sedalia, Mo.*

MASTER MECHANIC AND ELECTRICIAN.

I had been an art student in several of the large cities of the East for three seasons and considered myself to be a good draftsman. It was not, however, until guided by your instruction that I fully realized the lack of neatness and care which my old drawings betrayed when placed side by side with those which had been returned to me from the Schools. I can never give enough praise for your persevering corrections of my lettering, and am satisfied that any student can become a good draftsman, if he will follow your directions and note your corrections, *in less time than at any other regular drawing school.* I received my elementary education in three different languages, and have been a student all my life. I realize that a *common education fits a man for a good life, whereas a good technical education fits him for a good business.*

I am very much pleased with the practical results of my Course. I am now master mechanic and electrician of the Shelby Electric Co.—*Christian H. T. Hagelstein, Electrician, Shelby, Ohio.*

WAGES ADVANCED $25.00 A MONTH.

On April 13, 1893, I went to work as fireman with the Topeka Railway Power Co., and in the year 1896 I enrolled in the Schools. Within a year I was made second engineer and my wages advanced $25.00 a month, being now $75.00 a month. I have finished the Stationary Engineering Course, and will say that I never could have held my present position, but for my studies. I have placed a letter on file at the Schools for a better position, and they have found one for me in Michigan, which I am now considering. I am trying my final examinations for a Diploma, and will be a proud man when I receive it, for I will then be eligible for any position in my line. It gives me great pleasure to recommend The International Correspondence Schools to any one, as I have always found them willing to do more than they advertised.—*George H. Henderson, Stationary Engineer, Topeka, Kan.*

SECURES POSITION AS DRAFTSMAN.

I completed the Drafting Course in The International Correspondence Schools last September, and within a few weeks after its completion I secured a position drafting. Since then I have been able to do any of the work that has been required of me and find no difficulty competing with those who have studied drafting in technical schools and who have been engaged in this business no longer than I.

I can strongly recommend the Schools to any who are desirous of bettering themselves by a technical education, as I owe my success entirely to them.—*S. S. Baker, Draftsman, Allegheny, Pa.*

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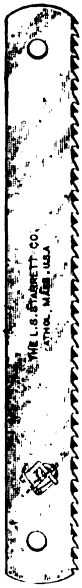

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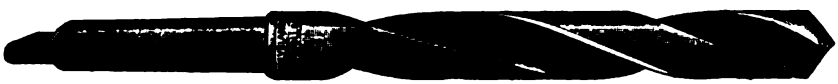

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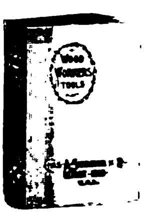

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Vol. IV. NOVEMBER, 1899. No. 10.

SCRANTON, PA., U. S. A.

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SCIENCE AND INDUSTRY

Vol. IV. NOVEMBER, 1899. No. 10.

A NEW DEPARTURE.

BELIEVING it to be for the best interests of our readers and advertisers, as well as for ourselves, we have decided to combine the three publications—"The Mechanic Arts Magazine," "The Steam-Electric Magazine," and "The Building Trades Magazine"—in a single publication under the title of SCIENCE AND INDUSTRY.

SCIENCE AND INDUSTRY will be a 64-page monthly magazine; its province will be to explain, in simple, clear, and concise language, the facts and principles underlying the construction and operation of machinery and of apparatus of every description, the applications of science, and the principles and practice of building construction.

The editorial staff will consist of Mr. J. J. Clark, M. E., Managing Editor, and the following gentlemen, each of whom is a specialist in regard to matters pertaining to his department: Mr. W. Scott-Collins, department of Structural Engineering and Building Trades; Mr. T. N. Thomson, department of Plumbing, Heating, and Ventilation; Mr. John A. Grening, department of Steam Engineering; Mr. R. B. Williamson, M. E., department of Electrical Engineering.

It will be the aim of the editors to make this magazine of interest and value to all classes; in order to accomplish this, the articles contributed to our columns will be kept as free as possible from technical language not readily understood by the majority of our readers.

The department of "Answers to Inquiries" will be a leading feature, 12 pages being devoted to answering the questions sent us by our readers. Owing to the large number of inquiries on hand and the new ones received with each mail, it is frequently two and three months from the date of receipt of the inquiry until it is published; but we answer all inquiries as promptly as we can, and, when possible, in the order in which they are received, provided the writers conform to the rules given on page 485.

The "Good Schemes" department will be discontinued, although we shall continue to publish really meritorious schemes from time to time, in the form of short articles, scattering them through the text. The heading "Chips and Spalls" will be retained, however, and conducted as heretofore in "The Building Trades Magazine."

It is our earnest desire that SCIENCE AND INDUSTRY shall prove acceptable to all subscribers to our former publications, and we shall endeavor to improve it in every department as the magazine grows older.

The subscription price will be 10 cents a copy, $1.00 a year. Those who remit $1.50 will receive, in addition to a year's subscription, a copy of "The Mechanics' Pocket Memoranda" or "The Building Trades Pocketbook," as they may select; or, for $2.50, a year's subscription and both pocketbooks. Subscribers to any of the three former publications will receive SCIENCE AND INDUSTRY until the date of the expiration of their subscription; those who have subscribed to more than one publication may have the amount of the unexpired subscription refunded to them, or may have it applied towards the purchase of any article selected from our premium list, as they may prefer.

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SCRAPBOOKS.

"Spacer."

SELECTING THE BOOK—USING SINGLE SHEETS AND BINDERS—READING BOTH SIDES OF THE SCRAP—CUTTING THE SCRAPS—THE ADHESIVE MATERIAL—THE INDEX.

I SUPPOSE that, sooner or later, everybody gets the scrapbook craze, but that, like the diary habit, few people keep it up. I shall not discuss in this article the advantages of keeping a scrapbook, beyond to remark that every person that wishes to be well informed should keep one. If one is especially interested in a particular subject (or subjects), he should not fail to preserve the articles relating thereto in one way or another.

The writer contracted the scrapbook fever many years ago, and has had touches of it, more or less severe, ever since. He knows many of the advantages and disadvantages of scrapbooks, and purposes to take the anxious public into his confidence regarding this matter. For the present, only what may be termed the "mechanical" features will be considered.

THE BOOK.

My first scrapbook was an old leather-covered account book—about 8 in. $\times$ 6 in. in size—that had formerly belonged to my grandfather. This I began when about 12 years of age, and the delight I experienced in cutting out scraps and pasting them in that old book was not to be measured by the results obtained. The chief defect of this, mechanically considered, was that the front part of the book bulged open far beyond the thickness at the back, owing to the additional thickness given to the leaves by the scraps. This defect I largely overcame in my second book—which was one of my grandfather's old ledgers—by tearing out a large number of the leaves. The defect just mentioned is entirely overcome by the use of the *Mark Twain* scrapbook. In this book the back is very much thicker than the front, the book containing but a small number of leaves, considering its thickness. On both sides of each leaf are parallel strips of gum (see Fig. 1), arranged in vertical columns. These scrapbooks are made in various sizes, and all that is necessary in order to attach a scrap is to moisten the strips of gum with a brush or sponge that has been dipped in water. These scrapbooks can be bought at any store dealing in stationery. The principal objections to them are, first, the price, which is rather high, considering the number of pages available for use; second, the scraps once being pasted in cannot be removed without soaking them off; third, if the scraps are to be read on both sides, as is frequently the case, they cannot be pasted in unless duplicates are at hand. If these objections are not considered, and it is desired to have a permanent book, there is nothing better than the *Mark Twain*.

FIG. 1.

A cheaper book may be obtained by purchasing a blank book (or having one bound for you) containing about 400 or 500 pages of rather heavy paper, and cutting out about half of them, leaving stubs about ¾ inch long. The second and third objections may then be overcome by cutting six slits whose length shall be a trifle longer than the width of the scrap—two near the top, two near the bottom, and two at the middle of the leaf, about ¼ or ⅜ of an inch apart; the scrap can then be inserted as shown at *a* and *b*, Fig. 2. For short scraps, four slits will be sufficient, as shown at *c*; while for very short scraps, two slits will be sufficient, as shown at *d* and *e*. The principal objection to this arrangement lies in the fact that the scrap must be pulled out in order to read the other side; another objection is that it detracts somewhat from the appearance of the book, though not as much as one would be likely to expect.

When it is necessary to read both sides of a scrap, and it is not essential that the scrap should be removable, a book such as business

men use to copy their letters in may be used. Although the paper is very thin—almost as light as tissue paper—it is very tough when dry, and is not easily torn. The side of the scrap pasted down can then be read as easily as the other side. A large portion of the

FIG. 2.

leaves in the back end of the book may be torn out, and the page numbers will then be consecutive. The writer has tried this and knows it to be a "good thing."

All of the foregoing methods of preserving scraps have one very serious objection: the scraps cannot be arranged so that similar subjects will be contiguous, unless they are allowed to accumulate until several hundred are on hand. It is then a long, hard task to arrange and sort them and paste them in. Of course the same amount of time is expended in the end, whether the scraps are pasted in as soon as cut, or whether they are allowed to accumulate and then pasted in all at once; but there is a very decided difference between spending five or ten

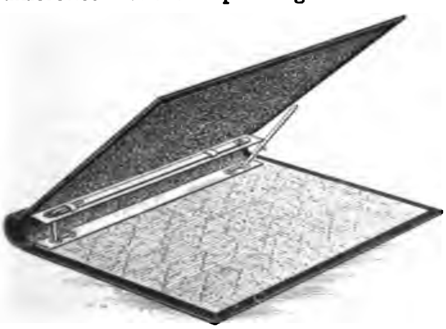


FIG. 3.

minutes of one's idle moments and spending one's evenings for several weeks. If the scraps are pasted in haphazard, nothing but an extremely elaborate index will enable one to find a particular article for which he may be looking. This objection, and all the others heretofore mentioned, may be overcome by going to a paper dealer and having him cut for you some heavy Manila paper in sheets about 9 inches wide by 12 inches long—say 500 or 1,000 sheets—and using these to paste the scraps on. The pasting can be done when the scraps are cut out, or at any time that may be convenient. Every sheet should have pasted on it a narrow strip, about $\frac{3}{4}$ inch or less in width, along the inside edge. This strip may be obtained when the sheets are cut. It will make up for the increased thickness caused by pasting on the scraps.

When a sufficient number of these sheets have accumulated, they may be sorted, arranged, and numbered, and then placed in a Shipman binder (see Fig. 3). If care be taken to punch the holes for the wires so that they will be in the same relative position on each sheet, the result will be a very neat looking scrapbook, and one from which any sheet may be removed with very little trouble. In case it is necessary to read both sides of a scrap, a cheap quality of tracing paper (not tracing cloth), such as is used by draftsmen, may be bought of any dealer

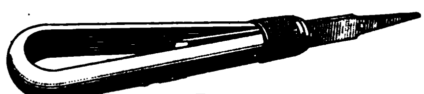


FIG. 4.

in draftsmen's materials, and cut into sheets of the size desired, the scraps being pasted on these instead of on Manila sheets.

To punch the holes in the sheets properly, a tool (which will be found very useful for many other purposes) like that shown in Fig. 4 may be used. This may be obtained from any hardware dealer, or from the maker, L. S. Starrett, Athol, Mass. A small wooden box should then be obtained, turned bottom side up, and two lines *a b* and *a c*, Fig. 5, drawn on it, at right angles to each other. Place a sheet on the binder, which should be opened so that the wires stand straight up, and so that the sheet will lie alongside of the wires and in its proper position relative to the ends of the binder, and place marks on the paper opposite the centers of the wires. Now lay the paper on the box so that the long edge will lie along the line *a b* and the short edge along *a c*, and draw short lines *e*, *e* opposite the marks on the sheet of paper. Finally, draw the line *f g* parallel to *a b*, about $\frac{1}{4}$ inch from it; at the points where *f g* crosses the lines *e*, *e*, and with the tool shown in Fig. 4, or an awl,

work holes d, d in the box. Since the lines fg, e, and e extend beyond the edges of the paper, they may be used as guide lines. Hence, to punch the holes in the sheets for the wires, place the sheet or sheets on the

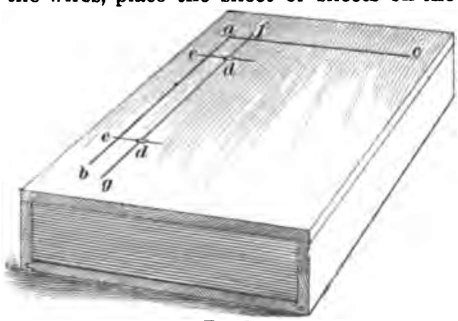


FIG. 5.

box, as above described, face upward; place the tool or awl on the line fg opposite one of the lines e, and punch; repeat for the other hole.

The Shipman binder can be had in any desired size. Any sheet can be readily taken out and replaced, and the resulting book (when the binder is filled) will present a very neat appearance. The writer has used many of these binders, and is aware of only one mechanical defect: when the wires are straightened out, after being bent, a kink is left in them; he got rid of the kinks by using pincers like those shown in Fig. 6, the jaws of which are always parallel. These pincers may be obtained at any hardware store, and may be used for many purposes that ordinary pincers are unsuited for. There is still another slight objection to these binders for scrapbook purposes: if the sheets are to be removed and replaced frequently, considerable time will be consumed and the holes will gradually enlarge. When the holes become too large, the strip that was pasted on each sheet may be soaked off and a new one pasted on.

A better arrangement, so far as ease of removal is concerned, is the Klip binder, made by H. H. Ballard, Pittsfield, Mass. Fig. 7 shows the klip and how it is used. No holes need be punched when using the binders. The klips are hardened steel springs, and hold the leaves by their tendency to close; they have a small hole on either side, into which short levers are inserted. The jaws of the klip are forced open by squeezing these levers together, as shown in the cut, until sufficiently far apart to enable the klip to be shoved over the binder; the levers (called *keys* by the maker) are then taken out. The klips may be used with or without the binder; in either case, they will hold the sheets very firmly—so firmly that, unless the klips are taken off, the sheets cannot be removed without tearing.

CUTTING OUT THE SCRAPS.

This is a detail that is often neglected. Nothing detracts more from the appearance of a book than the sight of uneven edges on the scraps. There is far more time spent in cutting out the scraps than one who has not noticed this would imagine. Shears are probably the greatest time wasters in this respect; they also produce the most uneven edges, unless one is an expert in their use. When using the shears, most people look at the point where the shears are cutting. If it is desired to cut a straight line, this is all wrong—look at the ends of the shears; keep the ends to the line, and the result will be as even an edge as can be hoped for. The greatest amount of speed can also be obtained by using the shears in this manner.

More satisfactory results, and greater speed, may be obtained by using a sharp knife and laying the paper to be cut on a straight-grained piece of pine, so that the knife will follow the grain when cutting. The chief objection to this method is that the knife must be sharp, and when used to cut paper, it dulls very quickly. Another objection is the necessity of using a board or wooden top of a table to cut on.

The best results are obtained by using the ordinary tin paper cutter. As these cutters are nearly always too short to do rapid work, the writer had one made for him out of a piece of thin sheet iron (see Fig. 8). He got a friend, who was a machinist, to cut it out for him and file the edges straight. The straight-edge part was made about 15 or 16 inches long and about 2 inches wide. With a cutter of this kind and a smooth, flat surface to work on, the scraps can be cut out very quickly and accurately. A yielding

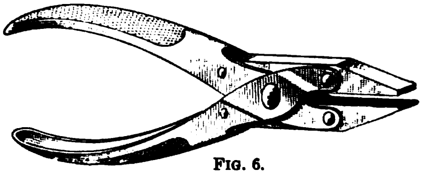


FIG. 6.

surface, such as is afforded by oilcloth or baize, is better than wood or stone, because it permits better contact between the paper and the cutter. Any smooth, flat surface will produce good results, however.

It requires a certain amount of practice to be able to use the cutter effectively and rapidly, but when the knack is once acquired, it will be found very useful. Two hints will suffice: be sure that there is good contact between the cutter and the paper, and between the paper and the surface it lies on; hold the free end that you are pulling in such a manner that the paper will produce the sharpest, clearest tearing sound when it is being cut. Practice holding the cutter with either hand; it will be found useful.

When an article to be preserved occupies more than one column of a paper, and there

FIG. 7.

are no cuts to illustrate it that it is desired to retain, it is best to cut the scrap into single columns at once, and pin the pieces together. There will then be no delays when pasting.

THE ADHESIVE MATERIAL.

The question of what kind of adhesive material to use is one to which the writer has given considerable attention, and it is one that has caused him considerable trouble. So far as its adhesive properties are concerned, common flour paste is as good as anything, when well made. There are two decided objections to its use: one is that it sours very quickly; hence, it cannot be used, except when a large number of scraps are to be pasted; the second is that the hands, and whatever the scrap rests on, get covered with the paste, and the result is very disagreeable. The ordinary mucilage that is sold in bottles—such as Carter's or Sanford's — works well, but is somewhat expensive. Pure gum arabic, dissolved in water to the proper consistency, is excellent and will keep indefinitely, but is also somewhat expensive. The best cheap material is dextrine; this is readily dissolved in either hot or cold water, and does not have to be cooked. The white variety is to be preferred to the yellow, on

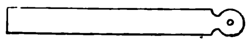


FIG. 8.

account of the color. It can be obtained at any drug store, and ten cents worth will last a long time. The writer has seen this keep without souring almost indefinitely, but has not been able to do it himself. Probably a few drops of oil of cloves or of carbolic acid would prevent it from souring. This, however, is a minor objection, because it is so easily made. It requires about twenty-four hours to dissolve. Library paste will keep a very long time before drying up; it also adheres well, but it takes too long to apply it. What is wanted is a fluid that will flow readily, adhere well, keep from souring, and be cheap. The first three conditions are fulfilled admirably by taurine mucilage, made by Chas. M. Higgins & Co., 168 Eighth St., Brooklyn, N.Y. It is not cheap, however.

Comparatively few people know how to apply the adhesive properly. It is not necessary or desirable that the entire surface of the scrap should be covered. All that is required is a narrow strip of the adhesive—about $\frac{1}{4}$ or $\frac{1}{2}$ inch wide, as preferred—running lengthwise of the scrap and close to the edges. If a brush is used to apply it, a camel's-hair brush will give the best results. The brush should be cleaned each time that it is used. A better way of applying the adhesive is to use a mucilage bottle such as is shown in Fig. 9.

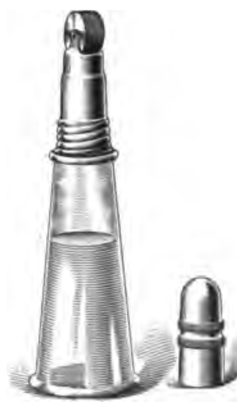


FIG. 9.

This bottle has a metal roller, on which the mucilage flows, and which is $\frac{3}{8}$ inch wide. All that is necessary is to remove the cap (which prevents the mucilage from drying up), touch the roller to the paper, and draw the bottle downwards. There is another bottle similar to this, but having a rubber roller instead of a metal

one. This one soon becomes clogged, unless used frequently.

THE INDEX.

If the scrapbook is made up of single sheets placed in a binder, as before described, so that similar subjects will come together, an index may not be considered necessary, but is nevertheless desirable. If the scraps are pasted in without regard to any particular arrangement, an index becomes almost a necessity. The best plan is to use a card index, and index each article as soon as it has been pasted in the book. One of the chief advantages of the card index is that the scrap can be indexed as soon as pasted and there is plenty of space to record the title and anything desired, such as the name and date of the paper from which the article was taken.

THE ART OF JOINT WIPING.*

Thos. N. Thomson.

HOW TO POUR ON THE SOLDER WITHOUT BURNING A HOLE IN THE PIPE—KEEPING UP THE METAL—SIMPLE METHOD OF WIPING.

THE male and female ends being now prepared and ready for joining, our plumber lays four bricks in line, apart, on edge, and crosswise to the line. The two pieces of pipe are laid in a straight line on these bricks in such a way that each piece is supported by two bricks, which, of course, brings the joint somewhere about midway between the two inner bricks, as shown by the illustrations. The object of placing the bricks on edge is to allow a space of 4 inches under the joint, which is plenty of room for a plumber's hand. If the bricks were laid flat, there would be a space of 2 inches only under the joint; and this, you know, is scarcely large enough for a child's hand. Common bricks are 8 in. $\times$ 4 in. $\times$ 2 in., and a plumber takes as naturally to bricks on edge as a duck takes to water.

After the pipes are "lined up" true, and the cleaned ends are pressed together so tightly that they form an almost water-tight connection without solder, the plumber immediately *fixes the joint*. This is his own language; it means that he fixes the parts to be joined so that they will not move while he is wiping the joint.

Now, plumbers are like other sensible people; they have lots of different ways of accomplishing certain ends. Sometimes they load down the parts to be joined with bricks, sometimes with monkeywrenches, Stillson wrenches, hammers, or even heavy goblets and buckwheat griddles, which all depends on where the plumber is working. All he wants for the time being is to put enough weight on the pieces of pipe to be joined to keep them steady while he is making the joint. And one thing is certain, every time: he gets his load from somewhere. Many bare-faced plumbers—sometimes called "smarties," but more appropriately termed "half-and-halfs," for their composition, if analyzed, is found to be half apprentice, half journeyman—try hard to make a gigantic show of their joint-wiping prowess, but their foolish failures furnish more mirth to the staid journeyman than a circus clown. Their joints will tumble down on them just as they are about to shout Excelsior! and then they swear and spend an hour or two more undoing the damage they have done, and making a new trial. "Half-and-halfs," as a rule, are good only for threading iron pipe and aggravating strikes. Owners of buildings pay handsomely for their experience. But why devote any more space to them?

Experienced plumbers always fix their joints perfectly rigid, and when they are wiped they never leak. The fixing our plumber did for the joint shown was of two kinds, purposely done for illustration. After he underpinned the bricks with slivers of wood, to prevent them rocking, he weighted the pipe next to his gasoline fire-pot with a piece of old lead water pipe weighing about 8 pounds, and an old lead pot piece of about the same weight. These made a load

*This is the second section of "The Art of Joint Wiping." The first was published in the October, 1899, issue of "The Building Trades Magazine," which now constitutes a part of SCIENCE AND INDUSTRY. The first section of this article treats on the *preparation* of a wiped joint by progressive stages, from the unrolling of the lead-pipe coil to the shaving and greasing of the parts to be joined; it covers 4½ pages, and is illustrated by five photographs of a plumber actually doing the work in a plumber's shop. Subscribers to SCIENCE AND INDUSTRY can get a copy of "The Building Trades Magazine" for October by immediately applying to the publishers of SCIENCE AND INDUSTRY, enclosing 10 cents. The stock of surplus magazines is very limited indeed, and those wishing them should apply at once.—ED.

of about 16 pounds, which is quite sufficient to hold that pipe steady, provided it is kept from rolling on the bricks by a rasp or file wedged in at each side. The other pipe, however, he steadied by pouring two bands of solder over it in such a manner that the abutments of these two little bridges might bear upon the two bricks at the left, as shown. This is a quick, lazy, inefficient plan of fixing, which nearly always injures the pipe when the bands are removed.

Fig. 1.—Pouring On.
Compare His Graceful Mien with that of the Novice.

Now the pipe is fixed. The plumber tries to shake it, but it does not move, so he lays an old newspaper under the joint, warms his wiping cloth by the fire, and stirs up the molten solder with his ladle, just to "feel the heat and see how it looks." The solder pot was put on the fire about three minutes before he commenced to fix the joint. Knowing the necessity for having good solder, and knowing the trouble that would undoubtedly follow should the metal be foul or defective in any way, our friend stirs the molten mass until all the lead and the tin, of which the solder is entirely composed, are so thoroughly intermixed as to form a uniform composition throughout the entire depth of the pot. He then pours a little of this solder on a brick having a smooth, level surface, producing a disk of molten solder about the size of a silver dollar, which shines like mercury until it begins to set, when it assumes a whitish, steel-gray, or some other indescribable color that you have got to see before you can realize. But on the surface and surrounded by this color are some four or five small silver-like spots about ⅛ inch in diameter. "These are the tin spots," says our friend, "and they give us a pretty fair idea of the quality of the metal. This solder is O. K.," he continues. "I am sure we will get a nice joint." If the proportion of lead and tin were not "just right," his little try piece would have a different appearance entirely. If it were *too fine*—that is to say, if there were an excess of block tin in the metal—the surface of the try piece would have more tin spots and perhaps also a silver-like ring all around the edge. Or, if the metal were *too coarse*, there would be a lack of tin spots, and perhaps a chalky-looking surface.

Fig. 2.—Getting Up the Heat.
This Action also Tins the Cleaning and Ensures a Tight Joint.

Everything being ready now and the wiping cloth warm, our bold friend commences to *pour on the solder*, using the ladle and wiping cloth, as shown in Fig. 1. Lead melts at about 600° Fahrenheit, and the solder in his ladle is probably about 800° F., so you see he must be very careful or he will most innocently melt a hole through the pipe and fill the bore with solder. But our friend knows all these little things, for his days of "solid joints" are over, and that is the reason he moves his ladle to and fro along the pipe as he slowly pours the hot metal on the soiling as well as on the cleaning. In this way he does not pour twice on the same spot before the heat in that spot is absorbed by the pipe. Amateur plumbers, tinsmiths, blacksmiths, and other dabblers

in water pipes are thoroughly noted for burning holes and making solid joints, and they seldom know their fault until the water is turned on and will not come.

As the plumber continues to pour on top,

FIG. 3.—FORMING THE JOINT.
Some Experts Do This Swiftly With the Left Hand.

some surplus metal runs down over the sides and falls on the newspaper, which keeps it from contact with the dirty bench. But you will notice in Fig. 1 that his left hand holds the wiping cloth under the joint. This catches some falling solder, which he occasionally pushes up against the under side of the joint to warm it. Of course the plumber knows enough to hollow his cloth and make it like a saucer, so that the molten metal will stay there; but the amateur cannot appreciate this kink until the melted metal runs into the palm of his hand and out between his fingers like so much beautiful quicksilver. The size of cloth commonly used is about 2½ to 3 inches square. If made of moleskin cloth it should be 6 or 8 ply thick, but if made of good bedticking it should be from 12 to 16 ply, for ticking is about one-half as thick as moleskin.

There are two prime objects aimed at in pouring metal on a joint: one is to properly heat the joint, and thus thoroughly tin all the cleaned surface before beginning to wipe for a finish; and the other is to have enough metal on to properly form and finish with. The plumber, therefore, is compelled to lift up the surplus metal periodically and place it on the top, as shown in Fig. 2; otherwise, the top would soon be bare and overheated, while the bottom would be overloaded with cold solder. This action, you will observe, rubs the plastic metal against the cleaned surfaces and tins them, besides producing a nearly uniform temperature all over the joint.

When enough heat has been applied to cause the solder to slide down and tend to fall off the joint in spite of the operator, and when there is more than enough metal to form the joint, the plumber immediately lays down the ladle and commences to shape the joint with his cloth. He must move his hand quickly, for the metal slides down rapidly and will not wait for him. He must work it up, and at the same time *find* the edges of the cleaning and form a rough outline of the joint. He must knock off all solder that has set on or near the wiping, so that it will not interrupt his movements. He must guard against the metal falling off the bottom while he is working at the top. In fact, he must look out for a dozen or more things at the same time, which are all liable to happen during the few seconds he has to wipe the joint after he lays down the heat-giving ladle. Then, when everything is "just so," he curves the cloth so quickly that you cannot see the action, and with almost lightning speed he swings it around the joint—first one way, then the other, as shown in Fig. 3. Before you can realize that the joint is now formed, he draws his cloth neatly over the top, as shown in Fig. 4, to remove any mark left by the swing, if any such there might be. With a sharp

FIG. 4.—FINISHING OFF WITH A CROSS-DRAW.
Many Plumbers Finish Off Tangentially With a Twitch.

twitch of the cloth all surplus material is whisked neatly off, and the joint is finished. But this is not all, for if he left it alone now to cool off slowly, the tin, whose temperature of fusion is much lower than that of the

other constituent of the alloy, would percolate down through the joint and fall off the bottom in measured drops, leaving a coarse, chalk-like porous joint with a deep hole in the bottom and a long sharp-pointed "teat" hanging from the side of it like a miniature icicle. The hole in the bottom will be a leak, and the teat is a warning. Time is yet an important factor, so our plumber instantly drops the cloth after making the cross-draw shown in Fig. 4, seizes a bit of an old looking-glass, holds it under the joint to see how it looks on the bottom, at the same time partly filling his mouth with water from a tin cup that is handy, he blows a strong fine spray all over the joint before a single drop has had time to form at the bottom. This spray rapidly chills the joint and instantly solidifies its outer surface. The joint is now wiped, but it must be allowed to cool for a few minutes before disturbing it; otherwise it may crack or break apart, and the whole operation would have to be repeated.

FIG. 5.—CHILLING THE JOINT.
The Wind and Spray Makes It Bright and Shiny.

I think I hear some of our readers say, "Humph! joint wiping is as easy as falling off a log." So it is; you are correct. It is just as easy to some people; but *they know how.*

Every intelligent mechanic knows that there is art in nearly everything he does. The carpenter has the art of pushing a plane so as to make a smooth, clean surface or a straight edge on a piece of timber; the stonecutter has the art of accomplishing the same results in stone with maul and chisel. The machinist can build engines so that they will run noiselessly and without overheating; the laborer has the art of swinging a pick and working a shovel all day long without killing himself. All these arts appear quite easy—but try them. Let the carpenter start in to hew stone, the stonecutter to build engines, the machinist to put in a few days with the pick and shovel, or the laborer to make window sashes, and see where they will all wind up. The carpenter would soon find his arm aching terribly and his eyes blind with stone dust; the stonecutter would have the engine so that no part would move when the steam was turned on, and there would be enough wheels left over to build another one; the machinist would be in the hospital ambulance within eight hours—a case of complete exhaustion due to an expenditure of five or six times as much energy as was really required to drop the pick or turn the shovel; and the laborer, whistling his wild airs, would spoil all the wood in the shop making hen ladders from detail drawings of window sashes. Neither man has the art of doing the other man's work—but he can do his own to perfection. Yet fools say, "there is no art in labor." Let them twaddle.

This reminds the author of one particular fool, who met his "Waterloo" in a plumber's shop. One of the journeymen had been working at the bench all forenoon wiping a large number of faucets on ⅝-inch lead pipe for a job. The bookkeeper, of course, was popping in and out all the time, with spectacles over his hooked nose, just like ordinary bookkeepers. After the plumber had wiped a number of joints, and the bookkeeper had taken them all in, over his glasses, with now and then a little jargon about the "ease of joint wiping," and when the plumber was just beginning to "pour on" for another joint the conceited bookkeeper had inflated himself to such a pitch as to state that "the thing was dead easy," and wanted to try it. Of course, plumbers are always very accommodating in such cases, so the bookkeeper had the ladle and cloth pushed into his thin bony hands before he could summon enough sense to retire, while, worst of all, the boys in the shop crowded around to see the fun, the writer being one of them. The bookkeeper knew his reputation was at stake now, and determined to uphold it to the bitter end. He stretched out his legs to an angle of about 15°, Napoleonic fashion, planted his feet as firmly on the floor as any 115-pound

bookkeeper can, and tried to keep his knees from knocking together. The solder was quite hot—just on the verge of being red. The handle of the ladle, although cool to the plumber, felt hot to the bookkeeper. And the wiping cloth, although large enough for the plumbers' big broad hand, felt altogether too small for the little bookkeeper. But he was brave, for his weight, and the reputation of the front office urged him on. He had seen the plumber manipulate the ladle and cloth repeatedly, and he tried hard to imitate the movements. He held his left hand under the joint, with his fingers crowded together as close as his soft sinews could pull them. He dipped up about half a ladle of molten solder and held it threateningly over the joint, all the time trying hard to assume a nonchalant attitude like that of our friend in Fig. 1. He knew the plumber poured slowly and steadily, and he tried to do the same, but it seemed as if the solder would not run out of the ladle. He slowly tipped the ladle more and more, just like a patient mother pouring out five drops of paregoric for her little boy with the "cramps," expecting all the while that the liquid was just about to drop. But it hesitated and clung together with fearful tenacity, until a point was reached where the force of gravity became more powerful than the attraction of cohesion, when the molten metal came out with a rush, flowing on the shaved part of the pipe in a steady stream. The bookkeeper was so astonished that he did not think, until a hole was burned through the pipe, to move the ladle to and fro. Then, of course, he blamed the solder for being too hot. However, he was game, for he asked another trial. It is needless to say that he got it. "I'll have to make a new one now, anyhow," says the plumber, "so you can go ahead and try your hand again." He did. When he had about half a pound of solder on the joint he began to lift it up on the side nearest him, just like our plumber in Fig. 2, and push it up on the further side; but as he tried the latter move, the solder on the top slid down over the side and into the palm of his hand. Then there was a scene. He instantly dropped his hand and the back of it came in contact with the plastic solder lying on the newspaper. This made matters worse. He dropped the ladle of solder on the floor, making us all jump, and pulled his wounded hand from under the joint with solder sticking even under his nails. We never knew how much pain the poor fellow suffered, for pain cannot be measured. Suffice it to say that he could not use that hand for at least two weeks.

Now, dear reader, if this little reminiscence frightens you, I would advise you not to try to learn how to wipe a joint. But if you are willing to take the necessary consequences without a murmur, then I would say: go ahead; try it. There is hope for you if you stick to it long enough.

THE END.

PROFESSOR BUNSEN.

ON WEDNESDAY morning, August 16, Prof. R. W. Bunsen, the celebrated chemist, breathed his last at his residence in Heidelberg, in the eighty-eighth year of his age. Bunsen's whole life was devoted to science, without any thought of making profit of his discoveries. He possessed a rare combination of mental sagacity and experimental skill, and his work is distinguished at once for its originality and for its exceeding accuracy. His discoveries in purely chemical science are second to those of no chemist of the century. To the investigations of those questions that lie on the border land between physics and chemistry he brought a depth of thought and a manipulative dexterity that have seldom been equaled. Though Bunsen was always a scientist, pure and simple, and steadily refused to be drawn aside from the pursuit of pure science, yet he made many discoveries of the highest practical importance, which have made his name familiar to many that are incapable of appreciating the delicacy of his chemical analytical methods. Bunsen's ice calorimeter, the Bunsen burner, and the Bunsen battery are inventions of such universal utility that they have made his name a household word. Prof. Bunsen's work as a teacher was, perhaps, of greater importance even than his original research; he inspired his pupils with unbounded enthusiasm, and won their highest admiration. Not only in Germany, but throughout the world, he is held in affectionate remembrance by many who have had the privilege of studying under him and have enjoyed the friendship of this great and good man.

CONNECTIONS FOR CONTINUOUS-CURRENT MOTORS.

R. B. Williamson.

Similarity Between Dynamos and Motors — Differences as Regards Operation — Connections for Shunt and Series Motors — Use of Starting Boxes.

THE continuous-current motor, as far as construction is concerned, is almost exactly the same as the continuous-current dynamo. This is particularly true in regard to motors used for indoor work, or, in other words, used in locations where a dynamo could ordinarily be operated. Motors have come into use for so many purposes, however, that it has been necessary to bring out a number of types of machines that differ considerably, as regards mechanical construction, from the ordinary dynamo. A good example of this is the ordinary street-railway motor; electrically, it possesses the same essential parts as a dynamo, yet one would hardly recognize it as such. Motors used for outdoor work, or those that are exposed to flying particles of any kind, must be enclosed as much as possible; this leads to the iron-clad type, so called because the field-magnet frame is made to surround the whole machine, with the exception, perhaps, in some cases, of the commutator.

Not only, in many cases, does the motor differ in mechanical design from the dynamo, but, from the nature of its operation the methods used for its starting and regulation are also different, and the object of this article is to take up briefly some of the points in connection with the starting of motors.

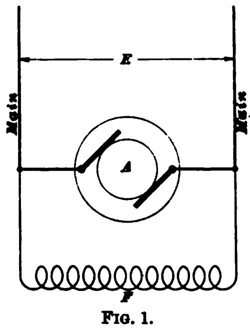


Fig. 1.

In the first place, we must consider briefly the types of motor that are in common use, and, in doing so, we will consider only those arrangements that are used to some extent commercially.

Direct-current motors may be operated on either constant-potential circuits or on constant-current circuits. One would be safe in saying that fully 99 per cent. of all electric motors are operated on constant-potential circuits. For example, all motors operated on ordinary incandescent circuits and street-car lines come under this class. The only constant-current motors that are used to any extent are those operated on arc-light circuits, and these are not used as much as formerly. Motors operated on arc circuits are, on the whole, not satisfactory, for reasons to be mentioned later.

Direct-current motors, like dynamos, may be either series-, shunt-, or compound-wound. Compound-wound motors are very seldom used, and they are not necessary, except in special cases, where very close speed regulation is required. Both series and shunt motors are operated on constant-potential systems. For constant-current circuits, the series motor only is employed.

The type of motor to be used for any given class of work will depend largely on the speed requirements. If the motor is to be operated on constant-potential mains, and if a nearly constant speed at all loads is desired, the shunt-wound motor will probably be used. This is the case with most motors used for stationary work, such as driving machinery, etc. If, however, a variable speed is desired, and especially if the motor is to be subjected to rough usage, it is best to use a series-wound machine. For this reason the series motor, operated from constant-potential mains, is used, almost exclusively, for the operation of street cars, hoists, electric traveling cranes, etc. Constant-current motors, when provided with an automatic governor, will run at a constant speed, and may therefore be used for similar work to which the shunt-wound constant-potential motor is adapted.

Dynamos are nearly always run at a constant speed, independent of the load; in fact, in most cases, it is extremely important that the speed should be kept just as constant as possible, and a great deal of attention has, for this reason, been paid to the design of the governors used on engines for electric work. On the other hand, a motor may or may not be required to run at constant speed, and, in cases where variable speed is required, some method must be used whereby the speed may be controlled at will. Where the motor is to be run at constant speed, no

outside speed-regulating device is necessary. Again, in starting up a dynamo, no special precautions are necessary. The engine is started and the dynamo gradually "builds up" or "picks up" its voltage. In starting

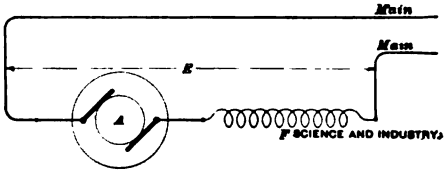


FIG. 2.

a motor, however, we are connecting a machine to mains between which there exists the full pressure generated by the dynamo, and we have to be careful how this is done. In order to accomplish this starting, without injurious effects to the motor, starting boxes are used. The starting box, or starting rheostat, is only used while the motor is being started, and is cut out of the circuit while the motor is running. The motor regulator, on the other hand, is in use all the time the motor is in operation.

We will consider, first, the use of the starting box in connection with constant-potential motors. It must be remembered, in the first place, that the resistance of a well-designed motor armature is very low—in most cases only a small fraction of an ohm. The armature is connected directly across the circuit when in operation, as shown in Fig. 1. This shows a shunt-wound motor, of which A is the armature and F the field, connected to the mains. The pressure E between these mains is kept constant by the dynamo, no matter what current the motor may be taking. If the armature of the motor were connected to the mains while the motor was standing still, the current that would flow through the armature would be equal to the electromotive force E divided by the resistance of the armature. Suppose, for example, the line pressure was 110 volts and the armature resistance .1 ohm. The current that would flow at the instant of starting would be 1,100 amperes, and this excessive current would at least burn the commutator, and, in all probability, burn out the armature. As the armature begins to turn, its conductors cut through the magnetic field and an electromotive force is therefore induced in them just as in the conductors of a dynamo. This induced electromotive force in a motor is, however, different from that set up in a dynamo in this respect, namely, that in a dynamo the electromotive force is always in the same direction as the current, and constitutes, in fact, the force that drives the current through the circuit to which the dynamo is connected; in the case of a motor, the electromotive force induced by the motion of the conductors through the field is always opposed to the current and tends to keep the current from flowing through the motor. For this reason it is often called the *counter* electromotive force of the motor. As soon, then, as the armature of the motor begins to revolve, it is at once capable of keeping out any excessive rush of current, because its counter electromotive force acts like so much resistance. When the motor attains full speed, its counter electromotive force becomes nearly equal to the electromotive force between the mains, though it never quite reaches the same value.

When a series motor is operated on a constant-potential circuit, as shown in Fig. 2, the action is much the same as that already described, although in the case of the series motor the rush of current would not be quite so great, because the field coil F, being in series with the armature, would, by virtue of its resistance and self-induction, choke back the current to a certain extent. It is necessary, however, to use a starting box with series motors, unless the motor is of very small size.

In order to prevent this rush of current, it is customary to insert an outside resistance in series with the armature and have this resistance so arranged that it may be cut out of circuit as the speed increases and the motor builds up a counter electromotive force capable of controlling the current without any outside assistance. When the motor has attained full speed, this resistance is, of course, cut out completely, as any resistance left in the circuit would only cause a useless waste of power and overheat the coils.

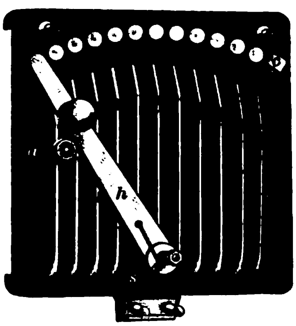


FIG. 3.

A great many different types of starting boxes have been introduced, each having its own peculiar type of construction. The earlier forms consisted simply of a number

of German-silver or iron resistance coils, placed in a wooden box and connected to a number of contact points so that the resistance could gradually be cut out, by moving a contact arm over these points. This construction was faulty in many respects; coils would get so hot that they sagged enough to touch each other, and in many cases the wooden box was burned. In modern boxes the construction is fireproof throughout, and the resistance wire is firmly held in place. A large number of patented arrangements have been brought out, the object of all of them being to obtain a box occupying small space, perfectly fireproof, and in which the wire would be held in place so that there would be no danger of short circuits, at the same time allowing ready radiation of the heat generated.

Fig. 3 shows a simple type of motor starting box in common use. In this box, the high-resistance "wire" is in the form of zigzag ribbon, and is attached to the back of the iron plate by means of insulating enamel. The iron plate serves, in this way, not only to support the wire but also to radiate the heat. In order to have it present a large surface to the air, it is made with ribs *r*. A number of the more important types of boxes will be described in a subsequent article, this article being intended to give only a general idea as to the use and connections of these boxes.

Fig. 5 shows the method of connecting up a simple starting box with a shunt-wound motor. This is a combination most largely used for stationary work. A fuse block *D* is connected as shown to protect the motor from overloads. *B* is a double-pole knife switch, and *C* the starting box. Shunt-wound motors are generally provided with three terminals. Terminal *1* connects to one brush and one terminal of the field, terminal *2* connects to the other end of the field, and terminal *3* connects to the other brush. The first point of the starting box is dead. One terminal of the main switch connects directly to terminal *1*; the other terminal of the switch connects to one terminal of the starting box. From terminal *2*, a wire leads to the same side of the switch to which the starting box is connected. The motor is started as follows: Having made sure that the lever of the starting box is at the off position, the switch *B* is thrown. This allows current to flow through the field, but not through the armature, and the field is therefore fully excited, so that, when the armature begins to turn, a counter electromotive force will at once be generated. The lever of the starting box is now moved over to the second point and current at once flows through all the resistance, through the armature, and thence to the other side of the switch. The resistance limits the current so that the motor starts up smoothly. As soon as the armature begins to turn, the counter electromotive force helps to keep down the current so that a portion of the resistance may be cut out, by moving the lever towards the right. In this way the resistance is gradually cut out, until finally the last point is reached and it is completely out of circuit. Care should be taken in making these motor connections, as mistakes are frequently made in connecting the field wire and the starting rheostat. The field wire is often connected on the other side of the box from that shown, so that the field is not excited until current begins to flow through the armature. Again, the mistake is sometimes made of connecting the starting box in series with the field instead of the armature, in which case, of course, there is trouble as soon as the switch is thrown. The connections are simple, but too much care cannot be taken to see that

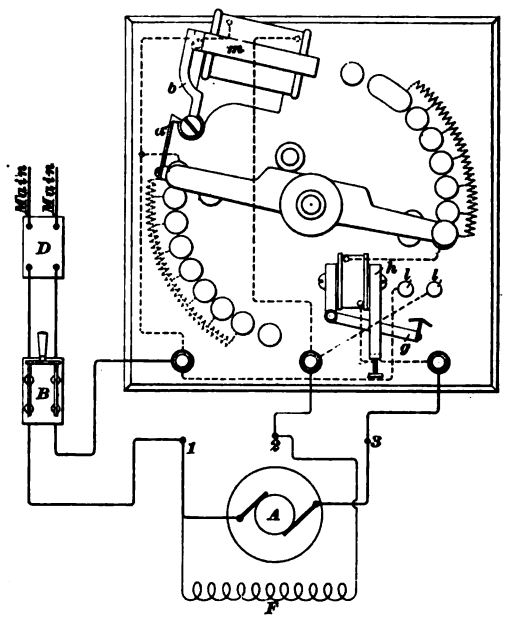


FIG. 4.

they are all right before attempting to start up the motor.

Fig. 6 shows the connections for a series motor. These are rather simpler than the

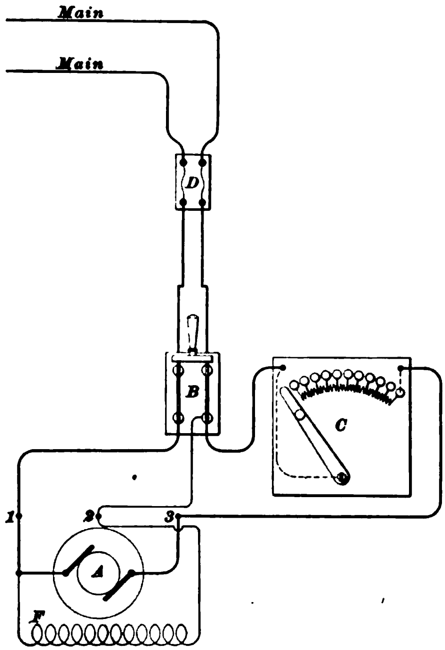


FIG. 5.

preceding, since the field is connected in series with the armature. In this case the starting box is connected directly in series with the motor and used in connection with a main switch and fuse block as before.

The starting box, in its simple form, does not always secure immunity from damage when starting. For example, suppose a motor has been shut down by pulling the main switch, and that the starting-box lever has not been moved back to the off position; the chances are that, when the motor is to be started again, the attendant will throw in the main switch without seeing that the handle is set back, and a short circuit will result. Again, the power may be shut off, for some reason or other, while the motor is in operation, and after a while turned on again. In this case, also, the lever will be at the on position and a short circuit will follow.

To overcome these defects various automatic boxes have been brought out, which will, of their own accord, go back to the off position whenever the motor is shut down or whenever the power fails. Many of these boxes are also fitted with a device that will automatically cause the starting lever to fly to the off position whenever the machine is overloaded. An automatic box of this kind, used in connection with a shunt motor, is shown in Fig. 4. The lever is here shown in the running position. This lever is moved over from the off position against the action of a spring placed in the hub, and is held in the position shown by a catch *a* fitting into a notch in the lever *b*. This lever is held down against the action of a spiral spring (not shown in the figure) by the magnet *m*, the exciting coil of which is placed in series with the shunt field of the motor. If the motor is shut down, or if the power is shut off in any way, the magnet *m* allows the armature *b* to fly up and release the lever, which at once flies back to the off position. The device shown in the lower right-hand corner is for protecting the motor against overloads. The magnet *h* is provided with a hinged armature *g*, carrying a copper contact piece, which makes contact between the projecting pins *l*, *l* when the armature is drawn up. The coil of the magnet is connected in series with the motor armature so that, when the current exceeds the allowable amount, the armature is pulled up. This short-circuits the coil of magnet *m*, thus releasing the lever and allowing it to fly back to the off position. A similar box is made for use in

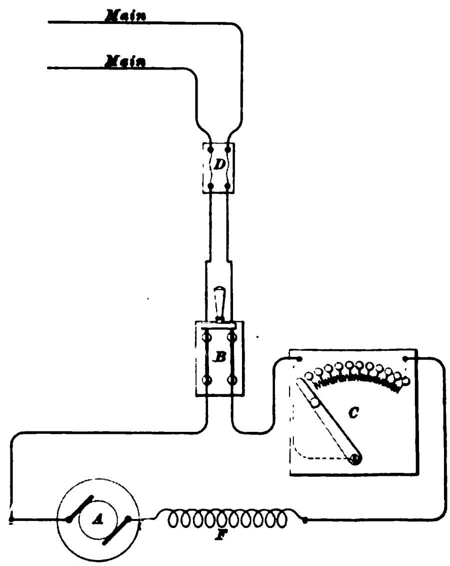


FIG. 6.

connection with series motors, the only difference being that both the magnet coils of *m* and *h* are connected in series with the armature.

The starting of a motor, run on a constant-current circuit, is a comparatively simple matter. This style of motor is usually connected in series with lamps on an arc-light circuit, as shown in Fig. 7, and the current is constant at all loads, because the automatic regulator on the dynamo varies the electromotive force as the load on the line varies. All that is necessary to start such a motor is to open the switch, which short-circuits the machine.

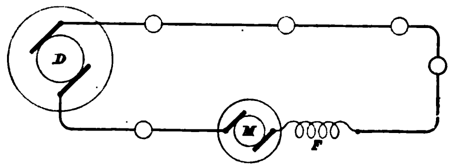


FIG. 7.

In fact, motors of this kind are cut in and out of circuit in just the same way as arc lamps. These motors are usually installed with two switches, as shown in Fig. 8. The switch *A* is placed outside the building, to cut off the current in case of fire, etc., and the switch *B* is used for starting or stopping the motor. Both these switches should be of the quick-break type commonly used in connection with arc-light circuits, and they should, of course, be so connected that they short-circuit the motor and *not open the circuit* when it is desired to shut down the machine. Motors operated on arc circuits are always more or less dangerous and are rarely ever used when constant-potential motors are available. If a constant-current motor be of considerable output, the potential across its terminals at full load becomes very high, not to mention the danger from grounds to which such motors are exposed. A 10-horsepower motor, for example, operated on a 9-ampere circuit, would have a voltage of about 830 volts across its terminals at full load.

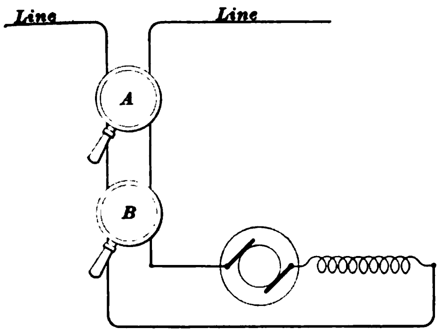


FIG. 8.

The starting devices described in this article apply principally to stationary motors. For railway motors, crane motors, etc., many special arrangements are used, but in every case it will be found that they are designed so as to insert resistance at starting and cut it out as the motor comes up to speed.

In conclusion, it may be well to mention, in connection with the use of starting boxes, that these boxes are not designed to be used as speed regulators. Many persons seem to think that a starting box may be used to vary the speed of the motor by leaving the starting lever on some intermediate point. If this is done, the box will surely be burned out, because they are not designed to carry current continuously. The resistance coils are only supposed to be in use for the short time necessary to get the motor under headway, and, if a speed regulator is needed, a box designed for continuous service must be installed. The spiral spring *s*, Fig. 3, is connected to the lever to prevent its being left on any intermediate notch in case any person feels inclined to try the experiment of using the box as a speed regulator.

SELF-PROPELLED VEHICLES FOR HEAVY TRAFFIC.

IN THE early part of the month of August a series of trials of self-propelled vehicles suitable for heavy traffic was held in Liverpool, England. The trials occupied two days, and were made over a course of 40 miles. According to the conditions, the distance between the depots for the supply of water did not exceed 12 miles, and all vehicles were required to traverse the same prescribed course and perform certain maneuvers. Steam was the motive power in each of the four competing vehicles; for fuel, one used oil, two used coal, and one used coke. The English manufacturers seem to have abandoned the attempt to use electric motors for wagons that are suitable for heavy traffic and for agricultural purposes.

ICE, WATER, AND STEAM.

(Concluded from the September, 1899, Number of "The Building Trades Magazine.")

"Plumbum."

How a Small Quantity of Water Bursts a Pipe—Interesting Experiments—Relative Volume of Steam at Different Pressures.

SOME plumbers, even at this late day, will tell you that a pipe bursts when the thaw comes on, but the most of them know different. Pipes burst when they freeze, and leak when they thaw. A frozen pipe does not leak, because the ice prevents the leak. But when the thaw comes, and the ice is melted out of the leak, then the plumber is notified; if he does not know any better, he claims that the thaw burst the pipe, and you can't change the poor fellow.

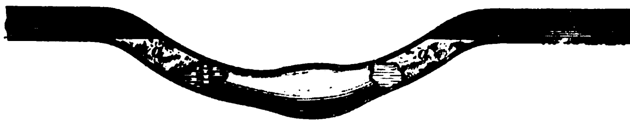


Fig. 5.

It is surprising how small a quantity of water is required to burst a pipe. Fig. 5 shows a little dip in an ordinary lead pipe, as commonly found at the back of laundry tubs. Suppose the owner of such a dip leaves his home for the winter months, and drains the pipes before he goes, to keep them from freezing. He forgets, or he does not know, that there are at least two dips in the pipes at the back of the tubs that cannot be drained, for the water must be blown out of them. They are neglected, however, and when he comes back they have frozen and burst.

It would be natural to suppose that such a small amount of water could not burst that pipe, particularly when the surface of the water is free to expand in the pipe, as the milk is free to expand in the mouth of the bottle. But there is a difference between milk and water—or at least there should be. The difference depends greatly on whether there is a milk trust in the town or not—the greater the trust the less the difference. Ice formed by the freezing of pure water is very dense, hard, and strong, and that formed by milk (syndicate milk excepted) is more spongy and yielding. The ice first forms on the surface of the water, as shown at *a*, *a*, and the expansion will then be upwards into the empty pipe, that being the path of least resistance. But as the plugs of ice *a*, *a* deepen in the pipe, the force required to overcome this resistance and cause them to move upwards will also become greater, until the increased pressure of the liquid in the pocket, due to this increased force, is sufficient to overcome the tenacity of the pipe, when it will swell and burst, as shown in the figure.

Now, take some ice, break it up, and put it in a saucepan, and push in a thermometer so that its bulb will be well surrounded by ice, as shown in Fig. 6. Place the pan on the kitchen stove, heat it slightly, and watch the thermometer. The ice will not begin to melt immediately, but the mercury for a little while will rise steadily. Then the ice will begin to melt. Directly this occurs, the mercury will stop rising and remain stationary until the ice is all melted. In plain words, the contents of the saucepan will not get any hotter, by the heat being applied to it, until all the ice is melted, which shows that the whole of the heat received from the fire is spent in melting the ice, and none of it makes the water or ice hotter. We can try that experiment as often as we please, but we shall always find that the mercury will stand at nearly the same point, which shows us that the temperature at which ice melts is always about the same; it varies almost imperceptibly, however, with the quality of the ice.

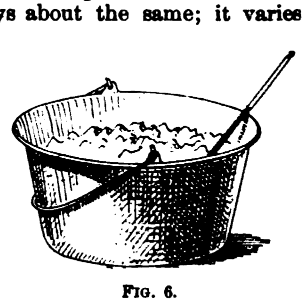


Fig. 6.

Suppose that the ice is all melted in the saucepan, and heat is still applied. We now notice that the mercury will rise in the thermometer, which shows that the water is becoming warmer. Continue the heat, and the mercury will continue to rise until the

water begins to boil. Directly the boiling begins, the mercury stops rising and remains stationary until all the water is boiled away. The temperature as read by the thermometer, when the water boils, is called the boiling point, and on different days this temperature varies slightly. It does not vary with the fire, the kettle, the stove, or the day of the week, but with the condition of the atmosphere, and the height of the kettle as compared with the level of the sea. In plain words, the pressure of the atmosphere affects the boiling point of the water. Try this experiment about the level of the sea shore in ordinary weather, and you will find that the boiling point is 212° F. on your thermometer, if it is correct. Suppose, however, you kindle a fire halfway up a mountain, and boil some water there; you will find, by taking the temperature with the same thermometer, that the point where the mercury rests, while boiling goes on, is at a much lower height. Then go up to the top of the mountain, repeat the experiment, and you will find that the water boils at a much lower temperature still, which all goes to show that as we go higher above the sea level, water boils at a lower temperature; indeed, when we get to the top of a very high mountain, it will boil when only tepid. The reason for this will be seen when we think a little about what boiling is. The simple fact of the matter is that the water, even when cold, is trying to turn into steam and expand in that form, but the atmospheric pressure, to an extent, prevents it. The greater the pressure, the more difficult it is for the water to change into steam. When the water is heated it tries harder and harder to turn into steam, till a point is reached where the pressure of the vapor of water just overbalances the pressure of the air, and then the water boils freely. You now begin to see why water does not always boil at the same temperature.

Numerous experiments and calculations have been made, and tables constructed, by which not only the boiling point of water is determined for different heights, but the heights of mountains can also be determined by boiling water at their summits. When water is boiled it expands enormously, 1 cubic inch of the liquid making about 1,647 cubic inches of steam at atmospheric pressure, 237 cubic inches at a pressure of 100 pounds by the gauge, and 31 cubic inches at a pressure of 1,000 pounds. (See Fig. 8.) The steam from an open kettle on the surface of the earth never has a temperature much higher than 212° F., because the pressure of the atmosphere seldom increases sufficient to make a noticeable difference; but down in deep mines, where the barometers indicate high pressures, the boiling point becomes much higher. To heat water to a higher temperature than 212°, we must confine it in a closed vessel and allow a pressure to bear down on the water; then its temperature will rise, and so will the temperature of the steam. This we can easily prove by the experiment shown in Fig. 7.

FIG. 7.

A piece of wrought-iron pipe *a*, having a common cap screwed on its lower end and a reducing T screwed on its top end, is partly filled with water and secured to a support as shown. A thermometer *b* is screwed into the side of *a* in such a manner that its bulb will be in the water. A pressure gauge *c* and a petcock *d* are screwed into the T outlets. A Bunsen flame is then placed under the cap to heat the water in *a*. To ascertain how pressure affects the boiling point, we will begin by leaving the cock *d* open, thus heating the water under atmospheric pressure. The water in *a* will absorb heat from the flame, and its temperature will rise, as can easily be observed by occasionally reading the thermometer. The pressure of the air above the water in the tube, however, remains unchanged. When the temperature of the water reaches 212° on the scale of the thermometer, it will be noticed that the mercury remains stationary for some time before the water actually begins to boil. This is due to the fact that the heat which

the water is then absorbing from the flame becomes latent in the water, that is to say, its presence cannot be detected by the thermometer. This heat is known as *latent heat.* When the water has absorbed enough heat to cause a portion of it to change its state and become a vapor, it will begin to boil, and the steam will flow freely through d to the outer atmosphere. The continued application of heat to the water in a does not raise its temperature any higher; it simply causes a continuous flow of steam through d to the atmosphere. At this point the thermometer still indicates 212°, and the gauge still points to zero. Let us close d and see what results we obtain. We soon begin to observe that the gauge indicates an increase in pressure and the thermometer a rise in temperature.

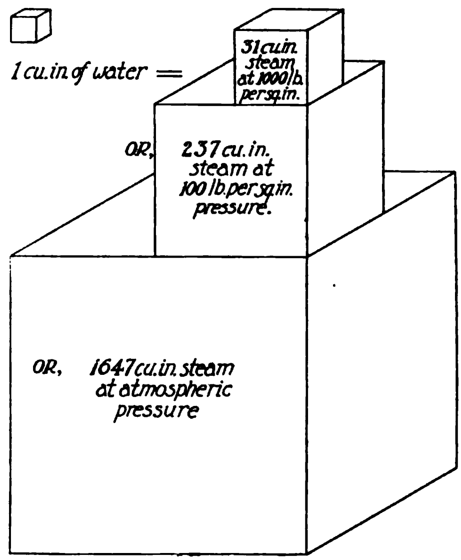


FIG. 8.

When steam is cooled it condenses again into water, giving off an enormous amount of heat, and this property of steam, combined with its adaptability to flow anywhere, is something that is taken advantage of in heating buildings, and causes steam to be an indispensable agent in the industrial arts.

For a final experiment take a piece of 1-inch gas pipe 18 inches long; screw a cap on one end and a reducing socket on the other. Pour some water in this tube, then place it in the fire, and connect the upper end with a hose to a pipe coil submerged in water, in a common wash tub. The water boils; steam is forced down the hose and through the coil where it is condensed, for the cold water around the coil absorbs heat rapidly from the steam. Very soon you will find that the water in the tub is becoming quite hot, and yet it is being heated by a comparatively small amount of water. If you calculate the results you will probably find that a pint of water evaporated from the tube and condensed in the coil will heat about 2 gallons of cold water so hot that you can scarcely put your hand in it.

PAY OF OLD-TIME ARCHITECTS.

AS NEAR as we can discover, the architect of "ye olden tyme" did not receive for his services a very exorbitant sum. Recently, some members of the French school at Delphi unearthed several slabs of marble, which bear inscriptions of great interest, dating as they do from the fourth century before Christ. The inscriptions, which cover about 200 lines, give the price of work for building operations in Greece at the period named, and from them we learn that an architect was paid at the rate of $150 per annum or less. This was little enough, surely, even if its purchasing power is multiplied, as it should be, five or six times. Sir Christopher Wren received for his services the magnificent sum of $1,000 per year for more than 20 years, while rebuilding London. His head draftsman received about $300 per year, while assistants received from $30 to $125 per year. French and German architects were not even so well paid at the same period. Bad as this was, it was better than the remuneration many of the older architects received, for in the far East if an artist made a noble design and erected a building worthy of admiration, his chances of being "suddenly removed" by order of the king were many. This step was taken in order to prevent a rival king from obtaining the services of an architect who might be able to so improve his plans that a finer and nobler building would be executed.—*Architecture and Building.*

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS.

A CONDENSED REPORT OF THE PROCEEDINGS OF THE NATIONAL CONVENTION, DAY BY DAY.

Tuesday, September 5, 1899.

THE eighteenth annual convention of the National Association of Stationary Engineers met at St. Louis, Mo., Sept. 5, 1899. At 10:45 A. M. the convention was called to order by the chairman of the local Arrangements Committee, Mr. Frank Eardley, who, with a few well-chosen remarks, introduced the Hon. Mr. Francis, ex-Governor of the State of Missouri. Mr. Francis welcomed the delegates to the great State of Missouri in a speech in which he referred to the coming Louisiana Purchase Exposition, promising that St. Louis would have the greatest exposition in the history of the world. He expressed the hope that every delegate and guest would return to attend the exposition of 1903, and in the meantime assist in advertising the exposition to the best of their ability. Frequent applause showed that these remarks appealed to the convention. Mr. John W. Lane, of New York City, Past President of the National Association of Stationary Engineers, in responding, told of the aims and objects of the association, dwelling at length upon the fact that it was an educational organization in every respect, and in no way whatsoever a labor union, as some people imagined. He spoke at length upon the part played by the engineer and his department, and the naval constructor, in the late Spanish-American war.

Brother Lane, in the most eulogistic terms, then referred to Gardner C. Sims, Chief Engineer of the naval repair ship Vulcan, to whose untiring efforts was due, in a large measure, the effectiveness of the fleet that defeated that of Cervera.

His Honor, Henry Ziegenhein, Mayor of St. Louis, was then introduced, and welcomed the delegates to the city of St. Louis in a speech of 10 minutes duration, which was received with tremendous applause. The Mayor spoke of the hospitality of St. Louis, and the good things invariably discovered there by delegates. He evoked great applause by telling them to get what they wanted, and if it were not given them, to take it anyhow.

Brother Herbert E. Stone, Chief Engineer of Harvard University, who is a member of Massachusetts No. 12, Boston, and the National Vice-President, responded to the welcoming speech of the Mayor, speaking briefly of the association and pleading for the loyalty of its members.

The National President, Mr. W. T. Wheeler, then assumed his station, and the convention was formally opened. As soon as the convention had come to order, Brother Einfeld, the National Doorkeeper, on behalf of Colorado No. 1, Denver, presented the National President with a beautiful silver-mounted gavel. After President Wheeler had thanked him in a few well-chosen words, he declared a recess at 11:35 A. M., to last until 12 o'clock noon.

SILVER-MOUNTED GAVEL.

When the meeting had been called to order, after adjournment, the first in the order of business was the roll call of the delegates. A quorum being present, the President called for the report of the Committee on Credentials. Brother Dill, chairman of the committee, announced that a majority of the credentials had been examined and found all right, but that, owing to the large amount of work still on hand, the committee could not render a complete report until late in the afternoon. President Wheeler then appointed the following committees:

Transportation.

J. G. Beckerleg	Ill. No. 1
Robt. Ross	N. Y. No. 24
Wm. T. Johnson	Mass. No. 1

Credentials.

Columbus Dill	Mass. No. 1
J. H. Van Arsdale	Mo. No. 2
C. C. Elsasser	Cal. No. 1

Mileage.

H. C. Hoffman	R. I. No. 5
J. G. Baril	Conn. No. 15
J. F. Steadman	Wash. No. 2
J. L. Jones	Ky. No. 5

Ways and Means.

T. R. Thompson	N. Y. No. 1
B. H. Dear	Col. No. 6
J. R. Chapman	Minn. No. 4
P. M. Knopp	Mo. No. 4
A. D. Howard	Ga. No. 1

Analysis and Distribution.

Judson Pratt	Ohio No. 15
W. F. Drinkut	Ind. No. 4
T. J. Bushell	S. Dak. No. 3

Appeals and Grievances.

C. W. Fellows	Texas No. 6
Wm. Tucker	N. J. No. 8
R. Donovan	N. H. No. 5

Auditing.

H. Rensford	Ohio No. 15
C. W. Dunham	Ill. No. 2
W. M. Logan	N. Y. No. 8
W. H. Frazier	Col. No. 1
J. S. Gillespie	Pa. No. 12

Ritual.

S. E. Nunn	Md. No. 2
J. Cooper	Mich. No. 16
G. Smith	N. J. No. 3
A. E. Wallis	Mass. No. 1
A. S. Wright	N. Y. No. 5

President Wheeler then read his annual message, in which he stated:

1. That the case of the National Association of Stationary Engineers against former National Secretary Dutcher for the embezzlement of $1,300 was still in the hands of the Illinois courts.

2. That in his opinion it would be wise for the convention to set aside the sum of $500, to be known as a Propagation Fund, said sum to be used at the discretion of the National President in defraying the expenses of those brothers whom he may send to organize subordinate associations.

3. That he had found it necessary to revoke the charter of Northwest Association No. 45, Illinois, on account of what he states to be a flagrant breach of trust.

4. That Brother Weston, a member of New Hampshire No. 5, Portsmouth, had been discharged from his position as engineer on account of a demand by the Brewery Workers' Union. Brother Weston refused to renounce his allegiance to the National Association of Stationary Engineers, and hence his discharge was demanded by the union under threat of a boycott or strike. To avoid such proceedings, the superintendent was forced to discharge Brother Weston. This case is now in the hands of a competent lawyer, who will attempt to bring it before the Supreme Court for trial during the October term.

5. That inasmuch as the National License Committee, in the opinion of many, has been seriously handicapped by the lack of funds, it is recommended that the sum of $1,000 be set aside for the use of the committee, to be expended at the discretion of the National President, Vice-President, and Secretary.

6. That in spite of the reduction of the per capita tax from 75 cents to 50 cents, and the decrease in the percentage receipts from the "National Engineer" from 30 per cent. to 25 per cent. that the trustees saw fit to make in March, 1899, there is nearly as much money in the treasury as on the corresponding date in 1898.

7. That, in consideration of the concession of 5 per cent. made by the trustees, the publishers of the "National Engineer" have opened an Eastern office, which, if properly conducted, it is believed will increase the amount turned over annually to the treasury.

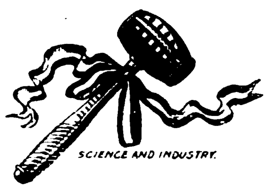
8. That praise is due to Brothers Fox, Hall, and Crain, of the Educational Committee, for the efficient manner in which they have performed their duties.

9. That it is recommended that, inasmuch as the present constitution has given general satisfaction and met the requirements of all fair-minded men, no changes be made that would necessitate the spending of hundreds of dollars required for the reprinting and distribution of a new constitution.

10. That in his opinion, instead of each association sending its own delegates to the convention, the state associations should elect delegates to the National Convention. This would mean a saving of thousands of dollars to the parent body and a proportionate saving to the local associations.

The message was duly referred to the Committee on Analysis and Distribution, and copies ordered to be printed and distributed forthwith to the delegates.

Brother Naylor, of Illinois No. 28, Chicago, the National Secretary, on behalf of Brother Edgar, who is at present in the Hawaiian Islands, with a neat little speech presented the National Association with a beautiful gavel made of different kinds of Hawaiian woods. The thanks of the association were tendered to Brother Edgar. This closed the morning session.



GAVEL OF HAWAIIAN WOODS.

The afternoon session was called to order at 3:15 P. M. In conformity with the order of business, the National Secretary read his report, showing the affairs of the association to be in first-class shape. He stated that the largest increase in membership during the past year was in Texas No. 7, San Antonio. North Dakota No. 2, Fargo, was credited with having spent the most money with the National Association.

DELEGATES TO THE EIGHTEENTH ANNUAL CONVENTION OF THE NATIONAL ASSOCIATION OF STATIONARY ENGINEERS.

There was a gain of 21 in the number of associations, there now being 297 associations in the United States.

The National Treasurer, Daniel Delaney, in his report showed the total receipts of the association to be $11,318.18; the balance last year, $2,845.19; expenses during year, $5,880.97; and the balance now in the treasury to be $8,282.40. This report was greeted with prolonged applause and then referred to the Auditing Committee.

There being a lull in the proceedings at this time, Brother Guenther, of New York No. 29, commenced to talk politics by moving that the word "political" be stricken from the preamble. This motion was ruled out of order. Adjourned to meet at 9 A. M. Wednesday.

LIFE AND ACCIDENT DEPARTMENT.

At 8 P. M. Tuesday, September 5, the meeting of the Life and Accident Department of the National Association of Stationary Engineers was called to order by Chairman William Mansen. The roll of delegates was then called and a quorum found present. The Secretary-Treasurer, Brother Ira Watts, now read his report for the last year, which was adopted as read. The Auditing Committee then rendered its report, complimenting the Secretary upon the efficient manner in which the accounts were kept.

The chairman now relinquished the chair to Brother John Trix. A motion to abolish all voting by proxy in the Life and Accident Department was carried. A motion to raise the age limit to 55 years was lost. The salary of the Secretary-Treasurer, which had been $600 per year, was raised to $800 per year. There being no further business before the house, the election of officers for the ensuing year was held, and resulted as follows: Secretary-Treasurer, Ira Watts; Trustee, Judson Pratt.

The claim of a disabled member for $500 was duly allowed. The house then adjourned *sine die* at 10:45 P. M.

Wednesday, September 6.

The opening feature of the session was a lecture delivered by William M. Moran, electrician for the Belleville and Suburban Street Railway Company, East St. Louis. The subject of the lecture was "Electricity." Brother Moran's lecture was received with applause, and great credit is due him for its careful preparation and most able delivery. At the conclusion of the lecture, President Wheeler called the convention to order. The first order was the election of a reading clerk. Brother Frederick Gielow, of Illinois No. 1, Chicago, was nominated for this position and elected by acclamation.

Brother Columbus Dill, Chairman of the Committee on Credentials, now read his report, recommending the seating of 227 delegates who had applied for admission with properly attested credentials. He also stated that this was the largest number of delegates that ever attended a convention of the National Association of Stationary Engineers, a statement that was received with tremendous applause. The roll of delegates was now read; when finished, the Committee on Credentials reported three protests against the seating of certain delegations. Missouri Association No. 14, St. Louis, protested against their own delegate; Michigan No. 1, Detroit, protested against their own association having 4 delegates, their finance committee claiming that the association was entitled to 3 delegates only; Wisconsin Association No. 3, Racine, filed a protest against seating delegates from the Wisconsin No. 20, Belle City Association, Racine. The protests were referred to the Committee on Appeals and Grievances.

Chairman Herbert E. Stone, Massachusetts No. 1, Boston, read the report of the Board of Arbitration. The board decided adversely to E. P. Gilroy, Deputy State President of Michigan, who had been removed from office by the National President and who had appealed to the Board. It also decided that Wisconsin Association No. 3, Racine, had no just grounds for their protest against Wisconsin No. 20, Belle City Association, Racine. The Board reported that the complaint registered by New York No. 5 against New York No. 15 was still under investigation, and that a decision would be rendered as soon as the Board could get all the facts.

The report of the Board of Arbitration was now referred to the Committee on Appeals and Grievances for further action. J. G. Beckerleg, Chairman of the Committee on Transportation, read his report, which was adopted as read.

The Committee on Education, through its chairman, Brother Chas. H. Fox, presented its report. It advised the association that in the educational contest carried on during the last year the prizes had been awarded as follows:

First prize, Iowa Association No. 8, Sioux City, 99 per cent.

Second prize, Louisiana Association No. 1, New Orleans, 98 per cent.

Third prize, Massachusetts Association No. 17, Lowell, 91.41 per cent.

Fourth prize, Ohio Association No. 45, Canton, 90.27 per cent.

Individual honors had been awarded to J. S. Gillespie, of Philadelphia, Pa., and H. H. Garman, of Akron, Ohio. The chairman advised the delegates that suitably engrossed diplomas had been forwarded to each of the associations named. The report having been adopted, the report of the Committee on Analysis and Distribution was read and referred to the Committee on Ways and Means for further consideration.

After an explanation of the present status of the case of the National Association of Stationary Engineers against the Bond Company on the bond of the former Secretary, Dutcher, who has defaulted in the sum of $1,300, the convention adjourned to meet again on Thursday.

The afternoon of Wednesday was given over to sightseeing. The local Arrangements Committee had provided for a trip to the St. Louis breweries, special cars having been placed at the disposal of the delegates and guests. After a delightful ride, the Lemp brewery was inspected, where suitable refreshments were served and the delegates presented with fans and other useful souvenirs. The convention now proceeded to the home of Mayor Ziegenhein, where an impromptu reception was held. Then, His Honor the Mayor leading, the Anheuser-Busch breweries were inspected. Here the photograph of the delegates was taken. Through the courtesy of Mr. Rosch, a photographer of St. Louis, we were enabled to get a copy in time for publication in this issue. Before leaving, refreshments were served and a suitable souvenir presented to all delegates and guests.

The evening was given up to a grand suburban theater party, tendered by the Brotherhood of Stationary Engineers of St. Louis in honor of the National Association of Stationary Engineers, which was under the direction of the following committee from the Brotherhood of Stationary Engineers: Edward Cole, T. G. Williams, E. C. Parker, W. E. Lyng, and C. H. Joyce. Special cars had been provided for the use of delegates and guests, and a very enjoyable evening was spent, which was due to the efforts of the Committee on Arrangements.

Thursday, September 7.

The convention opened at 9 A. M. with a lecture on "Pneumatics," by Prof. J. H. Kenealy, Department of Mechanical Engineering, Washington University, St. Louis, Mo. The lecture was a very able one, and the delegates and guests present manifested great interest in it. In the course of his lecture, Professor Kenealy gave a full description of the compressed-air system of the Metropolitan Street Railroad Company, New York, N. Y. The convention was now called to order by President Wheeler, and the Committee on Ways and Means reported. This report was referred back to the committee for further consideration. The Committee on Education followed, and in their report recommended the addition of a common-school curriculum to the educational work now carried on. The report was laid on the table. The Committee on Ritual reported progress.

Next in order was the report of the Committee on Appeals and Grievances on the Gilroy case. As this case attracted considerable attention, a short résumé will probably be appreciated by our readers. Brother E. P. Gilroy, Michigan No. 1, Detroit, a year ago was appointed Deputy President for the State of Michigan by National President Wheeler. At that time Brother Gilroy was a running engineer, but some time before the expiration of his term of office he left his position as engineer to accept a better position. Brother Gilroy communicated with President Wheeler and was informed that his commission would be revoked if he ceased to be a running engineer. Gilroy appealed to the local associations of Michigan, all but one of them requesting his continuance as Deputy President. Resolutions to this effect were passed and forwarded to President Wheeler. Yet, in spite of this action, the President saw fit to revoke the commission of Brother Gilroy, who appealed from the decision to the Board of Arbitration. This Board, as mentioned in the report of Wednesday's proceedings, sustained the action of the President. The matter being referred to the Committee on Appeals and Grievances, a majority report reversing the decision of the President was rendered. This report, in favor of Brother Gilroy, was finally adopted. On a vote, the delegates by an overwhelming majority decided that the stand taken by the President did not meet with the approval of the convention. Thus the precedent was established that the mere fact of an appointed officer changing his position for a different one in another line of business was not sufficient cause for removal. The Mileage Committee now

rendered its report, stating that the total miles traveled by delegates to this convention were 173,605, exceeding by 50,000 miles the mileage of any previous convention. They also recommended that the mileage be fixed at 4½ cents per mile. The report was referred back to the committee for further consideration.

At 12 o'clock sharp, three delegates bore into the hall a handsome clock surmounted by a carved figure, and two elaborate candlesticks. Brother J. H. Harris, of Chicago, in a neat little speech, presented the articles to President Wheeler in appreciation of his services, the present being made by the delegates and guests. A committee was now despatched to find Mrs. Wheeler and escort her to the rostrum. This having been done, President Wheeler responded to the presentation, accepting the gifts and thanking the donors for their generosity.

A vote of thanks was now tendered to the Brotherhood of Engineers of St. Louis, who entertained the convention Wednesday night at the Suburban Garden. The meeting then adjourned till 9 A. M. Friday, September 8.

For the afternoon the local committee had arranged for an excursion up and down the river. At 2 P. M., the fine excursion steamer City of Providence left the foot of Olive Street with about 500 delegates and guests, passing under the Eads bridge and Merchants' bridge and going up the river as far as the Chain of Rocks. Here it was intended that a landing should be made to inspect the water-works plant. Unfortunately, the river was so low that the pilot deemed it unsafe to attempt to make a landing. The boat now dropped down the river for about 10 miles, and then returned to the city, landing its passengers at 6:30 P. M. At 7:30 P. M. the boat started out again for a moonlight trip on the river, returning about 10 P. M.

Friday, September 8.

The day opened with a lecture on "Artificial Refrigeration," by Mr. Otto Luhr, of Illinois No. 38, Chicago. Brother Luhr gave a talk of about an hour's duration, which was listened to attentively by a large and appreciative audience. At 10 P. M., President Wheeler called the convention to order. The Committee on Ritual, through its chairman, Brother Wallis, reported in favor of abandoning the present elaborate ritual, and returning to the old ritual in use in 1896. After considerable discussion, the report was concurred in by a vote of 99 to 42. The Ways and Means Committee now rendered its final report, which was taken up section by section. The committee recommended:

1. That the officers of the association should try to collect on the bond of defaulting Secretary Dutcher, instead of prosecuting the defaulter. This recommendation was not concurred in, inasmuch as the case was already in the courts.

2. That a propagation fund of $500 be set aside, as recommended in the President's address. Concurred in.

3. That the course adopted in regard to Brother Weston, who was discharged from his position for refusing to join a labor union, be approved. Concurred in.

4. That the sum of $1,000 be appropriated for the use of the National License Committee. Not concurred in.

5. That the per capita tax remain at 50 cents per year. Concurred in.

6. That the reduction of percentage receipts from the "National Engineer," approved by the trustees, be approved by the convention. Concurred in.

7. That the improvements suggested by the Educational Committee, and the addition of a common-school curriculum, be approved. First section concurred in. Amplification of educational system not concurred in.

8. That no changes be made in the constitution. Concurred in.

9. That the recommendation of the President in regard to state associations be not approved. Ruled out on a point of order and constitutional grounds.

At the conclusion of the consideration of the report of the committee, Past President

GAVEL PRESENTED TO PRESIDENT WHEELER.

Lane stepped forward, and on behalf of Rhode Island Association No. 1, Providence, presented President Wheeler with a handsome gavel, the head of which represented what Brother Lane facetiously referred to as the national flower of Rhode Island, to wit, a clam. After a suitable response had been made, the Committee on Appeals and

Grievances, in the case of Missouri No. 14, recommended that the alternate be seated instead of the delegate. Brother J. W. Wood, the delegate in question, was then accorded the privilege of the floor, and in an eloquent speech made an excellent defense against both the report and the protest on which it was based. As a result, the recommendation of the committee was not concurred in, and Brother Wood was seated as a delegate.

In the case of Wisconsin No. 3 against Wisconsin No. 20, the committee reported that the matter had been settled amicably by both parties. The convention then adjourned.

The afternoon session was called to order at 2 P. M. The Committee on Mileage not being ready as yet to render its final report, by unanimous consent the matter of selecting a place of meeting for the nineteenth annual convention was taken up. The following cities contested for the honor: Atlanta, Ga.; Cleveland, Ohio; Detroit, Mich.; Milwaukee, Wis. A letter was also read, asking that the 1901 convention be held at Buffalo, N. Y. Milwaukee being the first city voted on, it was chosen unanimously.

The Committee on Mileage was again called, but still not being ready, by unanimous consent the election of officers was proceeded with, which resulted as follows: President, Herbert E. Stone, University Hall, Cambridge, Mass., member of Massachusetts No. 12, Boston. Vice-President, Patrick E. Leahy, 167 Twelfth Street, Long Island City, N. Y., member of New York No. 7, New York. Secretary, Geo. D. B. Van Tassell, 501 Wells Street, Chicago, Ill., member of Illinois No. 1, Chicago. Treasurer, Daniel Delaney, Idlewild, Cincinnati, Ohio, member of Ohio No. 36, Cincinnati. Conductor, C. C. Elsasser, 1133 Pierce Street, San Francisco, member of California No. 1, San Francisco. Doorkeeper, C. W. Fellows, 1805 San Jacinto Street, Houston, Texas, member of Texas No. 6, Houston. Trustee of "National Engineer," Frank Eardley, 1502 Market Street, St. Louis, Mo.

The Committee on Mileage now made its final report, which was adopted as read. A vote of thanks was extended to the management of the Southern Hotel, and the local committee for the courtesies shown. A standing vote of thanks was given to retiring Secretary Naylor in appreciation of the able manner in which he had performed his onerous duties. After the installation of officers, by Past President John W. Lane, the convention adjourned *sine die.*

THE NATIONAL OFFICERS.

William T. Wheeler, Past President.

Past National President W. T. Wheeler, who has just concluded his term of office as President, was born in Calais, Me., August 24, 1864. He received his education in the public schools and night schools. He began life in the machine shops of the Angel & Blake Manufacturing Company, New York, N.Y. In 1879 he entered the employ of the Equitable Life Assurance Society, where his ability was recognized by steady advancement until he became the assistant engineer of the Equitable Building, one of the largest and most important plants in New York City. This position he recently left to become chief engineer of the New York Life Building, 346–348 Broadway, New York, N. Y., a position of great responsibility. He is a member of the Phœnix Association, New York No. 24, New York City, of which association he has been Vice-President and has repeatedly been a delegate. For one year he was the Deputy President for New York State, a position which he filled with credit to himself and the order.

At the Columbus Convention, 1897, he was chosen National Vice-President, and at the Pittsburg Convention, in 1898, he was elected National President, a position he filled with credit to himself and with profit to the association.

Herbert E. Stone, National President.

National President Herbert E. Stone, of Cambridge, Mass., was born April 15, 1862, in the town of Bethel, Oxford County, Me. In conformity with the old saying, "Like father, like son," his father having been a mechanic, he at an early age entered the machine shop of a large corporation. At the age of 19, in order to gain experience in a different line of mechanical pursuits, he entered a large house in Boston making a specialty of installing large power and

heating plants. He remained for nine years with this concern, adding daily to his knowledge, and rising, step by step, until he was given charge of the installation of various first-class power plants throughout New England.

In 1886, 1887, and 1888 he was engaged at Wellesley College and Harvard University, installing their respective heating and ventilating plants.

In 1888 he was placed in charge of the plant of one of the largest and most complete breweries in Boston. He left this position to accept one as chief engineer of the House of Correction of Middlesex County, Mass. After serving four years at that place, he was appointed chief engineer of Harvard University, Cambridge, Mass., a position he is holding at present. There are forty university buildings, and in all of them the lighting, heating, and ventilation is under the supervision of Mr. Stone. On May 2, 1894, Mr. Stone became a charter member of the organization now known as Massachusetts No. 12, Boston. He was immediately appointed on the Office and Library Committee, and at the annual election held in December, 1894, he was elected President of the association, and served his full term. In 1896 he was National Deputy President, and since that was appointed Deputy President for the State of Massachusetts. He was also elected a member of the Board of Trustees of the "National Engineer," but resigned this office upon his election as National Vice-President at the convention held in Pittsburg in 1898. The National Association of Stationary Engineers has shown its appreciation, both of his faithful services in that capacity and the efficient management of his office, by unanimously electing him President for the ensuing year.

Patrick E. Leahy, National Vice-President.

The story of the life of the National Vice-President does not differ materially from that of all other successful men. Compelled early in life to earn his own living, he started as an apprentice in a machine shop. Like many of the brightest engineers this country has produced, whose early steam-engineering experiences were gained on the water, he followed the sea for a living for quite a while. The quality of self-reliance so predominant in the successful marine engineer, stood him in good stead when he abandoned the sea for a shore job, and in no small measure contributed to his steady advancement in his chosen profession. As early as 1884, he recognized the future importance of the electrical field and the necessity of a thorough knowledge of electrical work for one that desired to stand in the front ranks of steam engineering. With the same energy that characterizes all his undertakings, he set himself to work to master the details of electrical work in its relation to steam engineering—an undertaking in which he has been as successful as in all others. He is now engaged in that line of work, holding one of the best positions in the East. He early became identified with the National Association of Stationary Engineers; he is now President of New York No. 7, James Watt Association, New York City.

Daniel Delaney, National Treasurer.

National Treasurer Daniel Delaney was born in Covington, Ky., in 1855. Through the death of his father he was thrown on his own resources when but ten years old, and had not only to support himself, but also to assist in the care of his mother. For some years he worked steadily in factories and stores, and all his spare time was spent in studying engineering, partly at home and partly at night school. In 1872 he obtained a position as machinist in the repair department of a roundhouse, and soon thereafter engaged in steam engineering. Later he was placed in charge of the water stations of a railroad. In 1884 he was placed in charge of the engines of the Cincinnati Railway Steam Hoist, with headquarters at Cincinnati. Nine years ago he accepted his present position as engineer for the P. Eckert Company, a large candy establishment. About fourteen years ago, Brother Delaney

joined Ohio Association No. 2, Cincinnati. While a member of that association he held the offices of Corresponding and of Financial Secretary, and was a delegate to several conventions. Under National President Illingworth he held the office of State Deputy President, and under President Naylor, the office of District Deputy. Nearly six years ago Brother Delaney and several other members, believing that owing to local conditions another association in Cincinnati would further the interests of the National Association, organized Ohio No. 36, Excelsior Association. Brother Delaney was twice elected President of this association, and ever since has been the Corresponding Secretary. Brother Delaney has always been a diligent student of engineering, until today he is one the best informed men in the profession. His example has been nobly followed by the other members, as evidenced by the fact that Excelsior Association received the first diploma in the first educational contest inaugurated by the National Association of Stationary Engineers. Brother Delaney was elected National Treasurer at the convention held at St. Paul, Minn. He was reelected at Buffalo, N. Y.; Columbus, Ohio; Pittsburg, Pa.; and St. Louis, Mo.

Geo. D. B. Van Tassell, National Secretary.

On October 18, 1859, there was born at Canandaigua, N. Y., of the good old Holland stock spoken of by Washington Irving, a boy who lived to become the secretary of the greatest engineering association in the United States. His boyhood was spent both at Elmira and Watkins, N. Y. In 1869 his parents moved West, locating near Jackson, Michigan. When fifteen years of age he secured his first position, serving as fireman in a custom flour mill at Jackson. During the winter months he attended school, and at the age of seventeen he secured a position as clerk in a store, but having histrionic ambitions, the life of a clerk proved too tame. Hence, within a short time he went to Chicago and tried life on the stage, but after 18 months of hardship of the most distressing character, turned his back forever on that profession. Brother Van Tassell candidly states that it is his impression that the profession has suffered but very little from the dimming of so bright a star as himself, and so far as he, personally, is concerned, his meals have been a great deal more regular since he quit the stage. He next went back to firing, and soon tried his hand at locomotive engineering, remaining at railroading until 1883, when he became associated with the mechanical department of the Railway Exposition held at Chicago, being placed in charge of the boilers furnishing steam for the first electric railway in this country. He was given the position of night engineer by the Exposition Company for two seasons, spending the time between seasons on the locomotive. He next went into the shops of the Sperry Electric Company, and while with them helped to install the central lighting station which supplied the first electric light to the Chicago "Tribune." He next secured a position on the engineering staff, but, the station burning down, he went back to the Sperry shops, afterward leaving them to accept a position as engineer with the Standard Oil and Provision Company. Within a short time he secured a better position as engineer and machinist for the Anglo-American Paint and Color Company. From there he went in a like position with the Wadsworth-Howland Company, leaving them on receiving an appointment as Chief Engineer of the South Dale Building, Chicago. This position he relinquished to accept a position as chief engineer with the Western Wheel Works, which he now holds. Brother Van Tassell has always been of a studious turn of mind, having burnt no small quantity of midnight oil in his pursuit of engineering knowledge.

C. C. Elsasser, National Conductor.

National Conductor C. C. Elsasser was born June 1, 1867, at Baltimore, Md. In the spring of the succeeding year his parents moved to California, settling in San Francisco, where Brother Elsasser was educated in the public schools, graduating from them with high honors in 1881. In 1882 he was apprenticed to the machinist's trade. Fully recognizing the value of an education as a lever for promotion, he steadily attended evening school during the course of his apprenticeship. Attracted by the fascination of a marine-engineer's life, he got a

berth as oiler on the Pacific mail steamship City of New York in 1885. By close attention to his duties, he rapidly rose to the position of second assistant engineer of ocean steamers. He left the S. S. San Juan of the Pacific Mail Steamship Company in August, 1890, to accept a position on shore, and in April, 1891, entered the employ of the California Electric Light Company, now known as the San Francisco Gas and Electric Light Company, where he holds at present the position of engineer in what is probably the largest central station of the West. While in the discharge of his duties, Brother Elsasser had the misfortune to lose his right arm, on January 7, 1897. Being a member of the life and accident department, he received the benefits accruing to him under the constitution. On January 29, 1891, he became affiliated with California No. 1, San Francisco Association. The esteem in which he is held by the members was shown by his election to various offices of trust, until in 1898 the association honored itself and him by electing him President. He is also affiliated with the Marine Engineers' Beneficial Association, being a member of No. 35.

C. W. Fellows, National Doorkeeper.

National Doorkeeper C. W. Fellows was born November 9, 1867, at Ashtabula, Ohio. In 1871 his parents moved to Kansas. When old enough to choose for himself, he followed the bent of his inclination and engaged in steam engineering, soon taking up electrical work. His hard application to duty, and the success crowning all his efforts, due to his superior technical knowledge, being recognized by his superiors, he was rapidly advanced, and while still a young man was appointed engineer and electrician for the Electric Light and Water Company of McPherson, Kansas. This position he filled with credit to himself and profit to the company. In 1893 he relinquished his position and moved to Houston, Texas. He soon found a position suitable to his attainments, receiving the appointment of chief engineer and electrician of the Houston Printing Company, a position he has held for the last five years and is holding at present. He early became a member of the National Association of Stationary Engineers. The esteem in which he is held is evidenced by his serving last year as State Deputy President of Texas. Like all successful men in the engineering line, he spent all his spare time in study. He attributes his success entirely to his close application to study, stating that his perseverance in this direction has been the means of advancing him to his present position and standing in his chosen profession.

Frank Eardley, Trustee.

The term of Frank Eardley, trustee of the "National Engineer," expiring in 1899, he was unanimously reelected for another term. Brother Eardley is now 36 years old. He commenced life as a machinist, working at that trade in various shops in Philadelphia, until he attained the age of 21 years. Following his inclinations, he chose steam engineering as his life work, and has been engaged at it ever since, gradually rising step by step. In 1889 he entered the employ of the Philibert & Johanning Manufacturing Company, St. Louis, Mo., where he is now employed as chief engineer. Brother Eardley is a member of Missouri No. 2, St. Louis. The members of that association, in recognition of his sterling integrity, honored him and themselves by electing him President in 1895, 1896, and 1897. He is one of the most popular engineers in the city of St. Louis, and an earnest and indefatigable worker for the National Association of Stationary Engineers. As chairman of the local Committee on Arrangements at St.

Louis, he largely helped to make the last convention a success, and praise is due him for the efficient manner in which he caused all the features of the various entertainments for the delegates and guests to be carried out. Socially, he is very prominent in St. Louis, and he is also a member of the Knights Templars and Knights of Pythias.

THE MECHANICS OF CARPENTRY.

(Continued from the July, 1899, Number of "The Building Trades Magazine.")

Maurice M. Sloan.

Kinds of Bridges—Character of Trusses Employed—Dead and Live Loads.

PART XVI.

THE first exigency of a community is suitable highways, by which communication may be had with neighboring communities for the transaction of business, for social intercourse, or for the facilitation of military operations. Now, the first requisite of a good highway is that the bridges en route are capable of sustaining and transmitting the heaviest traffic that will pass over the highway, either probable or possible.

The highway bridge is of as ancient origin as the highway itself, and forms today, as it did in former times, an interesting problem for the constructor. In fact, of late years highway bridges have evidenced much skill in their design, the exercise of which was necessary, owing to the conditions of extreme economy, probability of loading, and appearance that had to be attained.

Highway bridges are constructed of stone, iron or steel, and wood. The former material is the most enduring, while the latter is the cheapest and best adapted to new and rapidly growing countries where timber is easily obtainable. In such districts, the probable increase of traffic in the course of a decade or so will require new provision to be made, while the present financial condition of the community does not allow the erection of an expensive structure to take care of the possible growth of traffic.

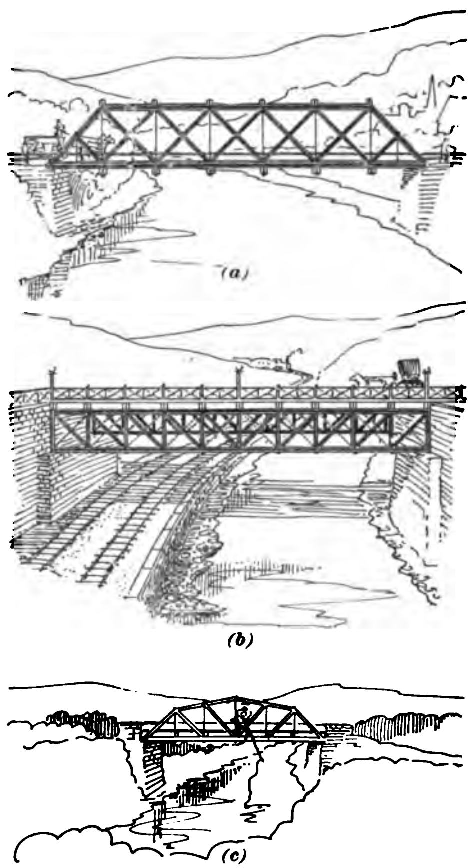


Fig. 67.

A *framed*, or *trussed*, bridge—the form generally adopted in the construction of wooden bridges—is composed of two or more trusses which lie in vertical planes, parallel to the line of the road. The upper and lower members are called the upper and lower *chords*. In a simple bridge truss, the upper chord is in compression, and the lower in tension, while the vertical and oblique members in the web are in compression and tension.

Truss bridges may be classified as through, deck, and pony. A *through bridge* is one in which the roadway is carried on the lower chords, and the travel passes between the two trusses, which are braced to each other at the top and bottom. A *deck bridge* carries the roadway on the top chords, and, as the roadway extends over them, the trusses may be placed nearer together than when employed in the through bridge. The trusses of a through bridge that lack sufficient height to allow of lateral bracing across the top are called *pony trusses*.

Such bridges are braced by the floor system, and must necessarily be of short span. These several classes of bridges are shown at (*a*), (*b*), and (*c*), Fig. 67.

The trusses generally employed in highway bridges of low cost are the Howe and Pratt,

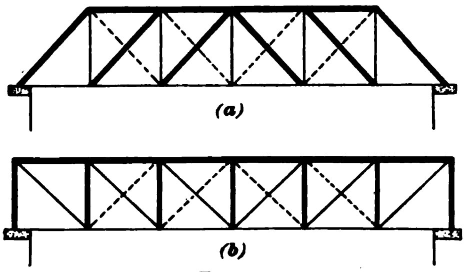


FIG. 68.

diagrams of which are shown at (*a*) and (*b*) in Fig. 68. Those members shown with heavy lines are in compression, and those with light lines are in tension, with such exceptions as will be explained later.

In the design of highway bridges, two loads are considered as acting vertically—the live and dead loads. The vertical trusses are designed to sustain the maximum stresses created by these loads. The bridge, besides carrying the vertical loads, must resist the horizontal force of the wind, and in order that it may do so, the trusses are braced to each other, usually at the top and bottom chord panel points, with lateral bracing. The panel points are where the oblique and vertical members connect with the top or bottom chords, and a panel is the space between two such points.

The floor system of a bridge consists of the floorbeams, stringers, and flooring. The floorbeams run at right angles to the line of travel, or perpendicular to the run of the trusses, and are usually laid on or secured to the chords at the panel points. The stringers run parallel with the trusses, and are hung from, or laid upon, the top of the floorbeams. The stringers support the roadway, usually of planks in highway bridges of wood. Reference to Fig. 69 will simplify some of the preceding definitions.

The *dead load*, which is permanent, consists of the entire weight of the bridge. This load must necessarily vary with the span and width of the bridge, the style of construction employed, and the live load that it is required to sustain. Since the dead load depends on the dimensions of the bridge members, which, from the nature of things, cannot be determined until the dead load is known, it must be assumed. After the stresses in the members, and, consequently, their sizes, have been determined from this assumption, and the details of the construction decided on, the assumed dead load must be checked, and, if found less than the actual dead load, sufficient material must be added to the members to insure their withstanding the additional stress. In assuming the amount of the dead load, recourse must be had to data relating to bridges of similar character and construction, and the weight figured accordingly; it being, of course, influenced by the points of difference existing between the structure in hand and the precedent considered. If no such data is obtainable, the values given in the following table will be found, in most cases, to cover the dead load per lineal foot for trussed highway bridges with about 16 feet roadway, constructed with wooden upper and lower chords, and web compression members, the tension members being of wrought iron.

TABLE VIII.

Span in Feet.	Dead Load per Lineal Foot in Pounds.
50	500
100	800
150	900
200	1,000

The *live*, *temporary*, or *moving load* on a highway bridge is due to the weight of people or vehicles passing over it. The greatest stresses occur in the trusses of a bridge when it is loaded with a densely packed crowd of people; while the floor system is usually subjected to its maximum load by the passing of a heavy road roller, or some similar piece of machinery or heavy vehicle.

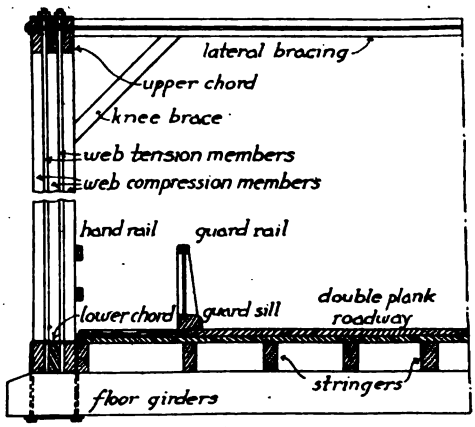


FIG. 69.

The amount to assume in estimating the live load is greatly influenced by the local

conditions; that is, whether the bridge is built in the city, where the traffic is likely to be congested, or in the country, where the population is sparse and heavy loads unlikely; and whether the rate of growth of the adjacent country makes heavier loads probable. The amount of the live load is also influenced by the span of the bridge; for the probability of a bridge of long span being densely packed with people is remote, while a bridge of short span will more than likely be subjected to such a load.

Bridge constructors differ as to the proper live load to assume in designing bridges. In France, 41 pounds per square foot is estimated on; while the more conservative practice in this country specifies 100 pounds per square foot and over. This load of 100 pounds per square foot is excessive where economy is demanded, especially in bridges of long span, as a load of more than 85 pounds per square foot will never be realized. The following table gives the live loads that may be assumed with safety in designing highway bridges.

TABLE IX.

Span in Feet.	City and Suburban Bridges.	Country Bridges.
0 to 50	100 pounds	90 pounds
50 to 150	90 pounds	80 pounds
150 to 200	80 pounds	70 pounds
200 to 250	70 pounds	60 pounds

The live load per panel in a highway bridge may then be determined by multiplying the product of the distance between panel points and the width of the bridge, both in feet, by the live load per square foot.

(To be Continued.)

ELECTRICAL STANDARDIZATION.*

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(*c*) Armature-resistance loss, which may be expressed by pI^2r; where r equals resistance of one armature circuit or branch, I equals the current in such armature circuit or branch, and p equals the number of armature circuits or branches.

(*d*) Load losses as defined in section 7. While these losses cannot well be determined individually, they may be considerable, and, therefore, their joint influence should be determined by observation. This can be done by operating the machine on short circuit and at full-load current, that is, by determining what may be called the "short-circuit core loss." With the low field intensity and great lag of current existing in this case, the load losses are usually greatly exaggerated.

One-third of the short-circuit core loss may, as an approximation, and in the absence of more accurate information, be assumed as the load loss.

(*e*) Collector-ring friction and contact resistance. These are generally negligible, except in machines of extremely low voltage.

(*f*) Field excitation. In separately-excited machines, the I^2r of the field coils proper should be used. In self-exciting machines, however, the loss in the field rheostat should be included, as above noted.

* Begun in the October, 1899, issue of "The Steam-Electric Magazine."

III. *Synchronous Commutating Machines.*

12. In synchronous converters, the power on the alternating-current side is to be measured with the current in phase with the terminal E. M. F., unless otherwise specified.

13. In double-current generators the efficiency of the machine should be determined as a direct-current generator, and as an alternating-current generator, as above noted. The two values of efficiency may be different, and should be clearly distinguished.

14. In synchronous converters, the losses should be determined when driving the machine by a motor. These losses are:

(*a*) Bearing friction and windage; see section 4.

(*b*) Molecular magnetic friction and eddy currents in iron, copper, and metallic parts. These losses should be determined at open circuit and at the rated terminal voltage, no allowance being made for the armature resistance, since the alternating and the direct currents flow in opposite directions.

(*c*) Armature resistance. The loss in the armature is qI^2r; where I is the direct current in armature, r is the armature resistance, and q is a factor that is equal to 1.37 in single-phasers, .56 in three-phasers, .37 in quarter-phasers, and .26 in six-phasers.

(*d*) Load losses. The load losses should be determined as above noted, with reference to the direct-current side.

(*e*) and (*f*) Losses in commutator and collector friction and brush-contact resistance; see sections 6 and 11.

(*g*) Field excitation. In separately excited fields, the I^2r loss in the field coils proper should be taken; while in shunt and series fields, the rheostat loss should be included, except where fields and rheostats are intentionally modified to produce effects outside of the conversion of electric power, as for producing phase displacement for voltage control. In this case, 25 per cent. of the I^2r loss in the field proper at non-inductive alternating circuit should be added as proper estimated allowance for normal rheostat losses; see section 6 (*f*).

15. Where two similar synchronous machines are available, their efficiency can be determined by operating one machine as a converter from direct to alternating, and the other as a converter from alternating to direct, connecting the alternating sides together, and measuring the difference between the direct-current input, and the direct-current output. This process may be modified by returning the output of the second machine through two boosters into the first machine and measuring the losses. Another modification might be to supply the losses by an alternator between the two machines, using potential regulators.

IV. *Rectifying Machines or Pulsating-Current Generators.*

16. These include: Open-coil arc machines, constant-current rectifiers.

The losses in open-coil arc machines are essentially the same as in sections 6 to 9 (closed-coil commutating machines). In alternating-current rectifiers, however, the output must be measured by wattmeter, and not by voltmeter and ammeter, since, owing to the pulsation of current and E. M. F., a considerable discrepancy may exist between watts and volt-amperes, amounting to as much as 10 or 15 per cent.

17. In constant-current rectifiers, transforming from constant-potential alternating to constant direct current by means of constant-current transformers and rectifying commutators, the losses in the transformers are to be included in the efficiency, and have to be measured when operating the rectifier, since in this case the losses are generally greater than when feeding an alternating secondary circuit. In constant-current transformers the load losses are usually larger than in constant-potential transformers, and thus should not be neglected.

The most satisfactory method of determining the efficiency in rectifiers is to measure electric input and electric output by wattmeter. The input is usually not non-inductive, owing to a considerable phase displacement and to wave distortion. For this reason the apparent efficiency should also be considered, since it is usually much lower than the true efficiency. The power consumed by the synchronous motor or other source driving the rectifier should be included in the electric input.

V. *Stationary Induction Apparatus.*

18. Since the efficiency of induction apparatus depends upon the wave shape of E. M. F., it should be referred to a sine wave of E. M. F., except where expressly specified otherwise. The efficiency should be measured with non-inductive load, and at rated frequency, except where expressly specified otherwise. The losses are:

(*a*) Molecular magnetic friction and eddy currents measured at open circuit and at rated voltage—Ir, where I is the rated current and r is the resistance of the primary circuit.

(*b*) Resistance losses, the sum of the I^2r of primary and of secondary in a transformer, or of the two sections of the coil in the compensator or autotransformer, where I is the current in the coil or section of coil and r is the resistance.

(*c*) Load losses, i. e., eddy currents in the iron and especially in the copper conductors, caused by the current. They should be measured by short-circuiting the secondary of the transformer and impressing upon the primary an E. M. F. sufficient to send full-load current through the transformer. The loss in the transformer under these conditions measured by wattmeter gives the load losses $+ I^2r$ losses in both primary and secondary coils.

(*d*) Losses due to the methods of cooling, as power consumed by the blower in air-blast transformers, and power consumed by the motor driving pumps in oil- or water-cooled transformers. Where the same cooling apparatus supplies a number of transformers or is installed to supply future additions, allowance should be made therefor.

19. In potential regulators the efficiency should be taken at the maximum voltage for which the apparatus is designed, and with non-inductive load, unless otherwise specified.

VI. *Rotary Induction Apparatus.*

20. Owing to the existence of load losses, and since the magnetic density in the induction motor under load changes in a complex manner, the efficiency should be determined by measuring the electric input by wattmeter and the mechanical output at the pulley, gear, coupling, etc.

21. The efficiency should be determined at the frequency and the input measured with sine waves of impressed E. M. F.

22. The efficiency may be calculated from the apparent input, the power factor, and the power output. The same applies to induction generators. Since phase displacement is inherent in induction machines, their apparent efficiency is also important.

23. In frequency changers, i. e., apparatus transforming from a polyphase system to an alternating system of different frequency, with or without a change in the number of phases, and phase converters; i. e., apparatus converting from an alternating system, usually single phase, to another alternating system, usually polyphase, of the same frequency, the efficiency should also be determined by measuring both output and input.

VII. *Transmission Lines.*

24. The efficiency of transmission lines should be measured with non-inductive load at the receiving end, with the rated receiving pressure and frequency, also with sinusoidal impressed E. M. F.'s, except where expressly specified otherwise, and with the exclusion of transformers or other apparatus at the ends of the line.

RISE OF TEMPERATURE.

25. *General Principles.*—Under regular service conditions, the temperature of electrical machinery should never be allowed to remain at a point at which permanent deterioration of its insulating material takes place.

26. The rise of temperature should be referred to the standard conditions of a room temperature of 25° C., a barometric pressure of 760 millimeters, and normal conditions of ventilation; that is, the apparatus under test should neither be exposed to draft, nor enclosed, except where expressly specified.

27. If the room temperature, during the test, differs from 25° C., the observed rise of temperature should be corrected by ½ per cent. for each degree C. Thus, with a room temperature of 35° C., the observed rise of temperature has to be decreased by 5 per cent., and with a room temperature of 15° C., the observed rise of temperature has to be increased by 5 per cent. The thermometer indicating the room temperature should be screened from thermal radiation emitted by heated bodies, or from drafts of air. When it is impracticable to secure normal conditions of ventilation on account of an adjacent engine, or other source of heat, the thermometer for measuring the air temperature should be placed so as to indicate fairly the temperature that the machine would have if it were idle, in order that the rise of temperature determined shall be that caused by the operation of the machine.

28. The temperature should be measured after a run of sufficient duration to reach practical constancy. This is usually from 6 to 18 hours, according to the size and construction of the apparatus. It is permissible, however, to shorten the time of the test by running a lesser time on an overload in current and voltage, then reducing the load to normal, and maintaining it thus until the temperature has become constant.

In apparatus intended for intermittent service, as railway motors, starting rheostats, etc., the rise of temperature should be measured after a shorter time, depending on the nature of the service, and should be specified.

In apparatus that, by the nature of their service, may be exposed to overload, as railway converters, and in very high voltage circuits, a smaller rise of temperature should be specified than in apparatus not liable to overloads, or in low-voltage apparatus. In apparatus built for conditions of limited space, as railway motors, a higher rise of temperature must be allowed.

29. In electrical conductors, the rise of temperature should be determined by their increase of resistance. For this purpose, the resistance may be measured either by galvanometer test or by drop-of-potential method. A temperature coefficient of .4 per cent. per degree centigrade may be assumed for copper.* Temperature elevations measured in this way are usually in excess of temperature elevations measured by thermometers.

30. It is recommended that the following maximum values of temperature elevation should not be exceeded:

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* By the formula $R_T = R_t(1 + .004\,\theta)$. Where R_t is the resistance at room temperature, R_T the resistance when heated, and θ the temperature elevation $(T-t)$ in degrees centigrade.

Commutating machines, rectifying machines, and synchronous machines: Field and armature, by resistance, 50° C. Commutator and collector rings and brushes, by thermometer, 55° C. Bearings and other parts of machine, by thermometer, 40° C.

Rotary induction apparatus: Electric circuits, 50° C., by resistance. Bearings and other parts of the machine, 40° C., by thermometer.

In squirrel-cage or short-circuited armatures, 55° C., by thermometer, may be allowed.

Transformers for continuous service: Electric circuits, by resistance, 50° C.; other parts, by thermometer, 40° C., under conditions of normal ventilation.

Reactive coils, induction and magneto regulators: Electric circuits, by resistance, 55° C.; other parts, by thermometer, 45° C.

Where a thermometer, applied to a coil or winding, indicates a higher temperature elevation than that shown by resistance measurement, the thermometer indication should be accepted. In using the thermometer, care should be taken to so protect its bulb as to prevent radiation from it, and, at the same time, not to interfere seriously with the normal radiation from the part to which it is applied.

31. In the case of apparatus intended for intermittent service, the temperature elevation that is attained at the end of the period corresponding to the term of full load should not exceed 50° C. by resistance in electric circuits. In the case of transformers intended for intermittent service, or not operating continuously at full load, but continuously in circuit, as in the ordinary case of lighting transformers, the temperature elevation above the surrounding air temperature should not exceed 50° C. by resistance in electric circuits and 40° C. by thermometer in other parts, after the period corresponding to the term of full load. In this instance, the test load should not be applied until the transformer has been in circuit for a sufficient time to attain the temperature elevation due to core loss. With transformers for commercial lighting, the duration of the full-load test may be taken as 3 hours, unless otherwise specified. In the case of railway, crane, and elevator motors, the conditions of service are necessarily so varied that no specific period corresponding to the full-load term can be stated.

INSULATION.

32. The ohmic resistance of the insulation is of secondary importance only, as compared with the dielectric strength, or resistance to rupture by high voltage. Since the ohmic resistance of the insulation can be very greatly increased by baking, but the dielectric strength is liable to be weakened thereby, it is preferable to specify a high dielectric strength rather than a high insulation resistance. The high-voltage test for dielectric strength should always be applied.

33. *Insulation Resistance.*—Insulation-resistance tests should, if possible, be made at the pressure for which the apparatus is designed.

The insulation resistance of the complete apparatus must be such that the rated voltage of the apparatus will not send more than $\frac{1}{1000000}$ of the full-load current, at the rated terminal voltage, through the insulation. Where the value found in this way exceeds 1 megohm, 1 megohm is sufficient.

34. *Dielectric Strength.* — The dielectric strength or resistance to rupture should be determined by a continued application of an alternating E. M. F. for 1 minute. The source of alternating E. M. F. should be a transformer of such size that the charging current of the apparatus, as a condenser, does not exceed 25 per cent. of the rated capacity of the transformer.

35. The high-voltage tests should not be applied when the insulation is low, owing to dirt or moisture, and should be applied before the machine is put into commercial service.

36. It should be pointed out that tests at high voltages, considerably in excess of the normal voltages, are admissible on new machines, to determine whether they fulfil their specifications, but should not be made subsequently at a voltage much exceeding the normal, as the actual insulation of the machine may be weakened by such tests.

37. The test for dielectric strength should be made with the completely assembled apparatus and not with its individual parts, and the voltage should be applied as follows: *First*, between electric circuits and surrounding conducting material; and, *second*, between adjacent electric circuits, where such exist, as in transformers.

(To be Continued.)

EASY LESSONS IN HAND RAILING.

(Continued from the October, 1899, Number of "The Building Trades Magazine.")

Morris Williams.

HAND RAIL FOR A STAIRWAY WITH CURVED STRINGER—FACE MOLDS AND JOINT BEVELS.

THE plan shown in Fig. 54 represents a stairway with a curved stringer, and containing within the curve six swelled or curved steps, each step of equal width, but less in width, at the rail, than the steps

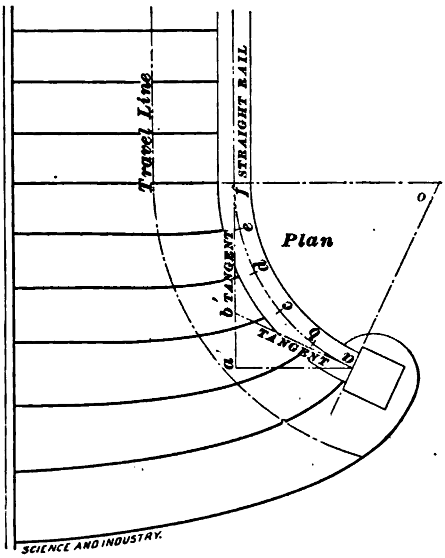


FIG. 54.

of the straight portion of the stairway. The newel is placed on the first step. This arrangement will cause the pitch of the wreath to deviate from the pitch of the flight as shown in Fig. 55, where, also, is shown the bevel m, which is to be applied to the side of the wreath to form a square butt joint. This treatment of the joint in workshop parlance is termed "forcing the joint."

To draw the plan in Fig. 54, from o as center describe the curves of the rail, and on the center line of the rail place the dimensions of the treads, as at a, b, c, d, e, f. Continue the center line of the straight rail through f to a'. Draw $a'\,a$ square to $a'f$ and $a\,b'$ square to $a\,o$.

Proceed to draw the elevation as shown in Fig. 55. Reproduce the plan of the center line of rail and tangents from Fig. 54. Place the divisions of the steps on $X\,Y$, as at o, a, b, c, d, e, and f. At f draw the perpendicular line ff', and make it equal in height to the total height of the seven risers contained in the curved portion of the stringer. Complete the elevation of the steps by drawing horizontal lines from o'', a'', b'', c'', d'', and e'' to intersect the vertical lines drawn from o, a, b, c, d, and e on $X\,Y$. Draw the pitch line $c'\,b'\,a'''\,g$ at a distance from the apex of each step equal to half the depth of the rail, intersecting the line of the newel at g, where the rail would strike it if both tangents were left equally inclined, as at $g\,b'$ and $b'\,c'$. If it is determined to raise the rail to point d', all that is required is to connect d' to b', thus determining the length and pitch of the bottom tangent. Draw the ground line $X\,Y$ through d'. At d' draw $m\,n$ square to the bottom tangent, thus forming the bevel that is to be applied to the end of the wreath connecting to the newel. Observe that $m\,n$ in the figure has been drawn, inadvertently, in advance of the point d'. If the bottom

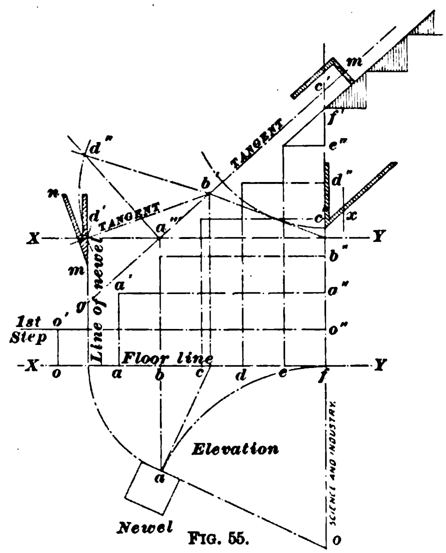


FIG. 55.

tangent were level it is evident that this bevel would not be required; the bottom tangent in that case would butt against the newel at right angles, as was shown in Fig. 52 in the October, 1899, number of "The Building Trades Magazine."

To find the form of the face mold, it is required to transfer the bottom tangent to the development, so as to find the angle between the two tangents on the face mold. From point a''' draw the dotted line $a''' d''$ square to the upper tangent. From b' as center, and the length of the bottom tangent $b' d'$ as a

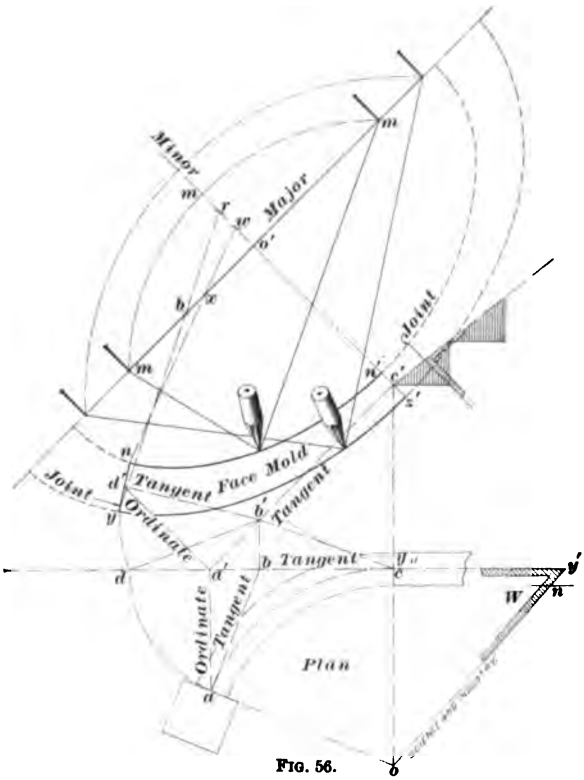


FIG. 56.

radius, revolve d' to d'', and connect d'' and b'; the line $d'' b'$ is the bottom tangent transferred to the development as required, and the angle $c' b' d''$ is the angle between the tangents of the face mold.

In Fig. 56, the tangents in the latter position are reproduced, and a plan of the rail is drawn. To draw the curves of the face mold, we will need to find the minor and major axes, and the width of the mold at the ends d' and c', as also that at the minor axis. The minor axis may be found by drawing a line from o (the center whence the plan is drawn) parallel to the ordinate $a a'$. Note that this is the method of finding the minor axis in all our figures. This line will cut the pitch line in c'; draw $c' o'$ square to the upper tangent $c' b'$, and make it equal to $c o$ of the plan. The line $c' o'$ is the minor axis. Draw the major through o' and square to the minor, as shown.

To find the width of the face mold at the end c', make $c' n'$ and $c' z'$ equal to half the width of the rail on plan; $n' z'$ is the same width as the rail on plan, owing to point c' being on the minor axis $c' o'$.

To find the width at the end d', take the length of $y' n$ from the bevel and place it on each side of d', as shown at $d' n$ and $d' y$.

Before the inside and outside curves can be drawn, it is further required to find the correct length of the semimajor axis. Take the length $n' o'$ of the semiminor axis of the inside curve as radius, and the point n at the end d' of the face mold for a center; extend to cut the major in x and continue the line $n x$ to w on the minor axis; the dotted line $n w$ will be the correct length of the semimajor axis for the inside curve.

To find the foci of the ellipse, take the length of the semimajor $n w$ for a radius, and the point n' on the minor for a center, and describe the arc $m m m$, cutting the major axis in m and m. By a similar process, the length of the semimajor axis and the foci of the ellipse for the outside curve may be obtained, as is clearly shown in the figure.

To find the bevel, take the point c' as a center, extend the dividers, touching the line $b' c$, and turn over to y''. Take the length $y'' c'$ for the altitude of a right-angled triangle, and the radius $o c$ of the plan for the base; the bevel will be found at W, the upper angle of the triangle.

Fig. 57 is presented to further illustrate the constructive lines made use of in Fig. 56. It clearly demonstrates the property of the ordinates $a a'$ and $a' d'$. In geometric language the ordinate $a a'$ is the horizontal trace of the oblique plane $a b' c' o'$.

If the development is folded on the pitch line $a' b' c'$, the ordinate $a' d'$ will coincide with the ordinate $a' a$, proving the point a' to be common to both plan and development. The tangent $b' a$, also, will coincide with the tangent $b' d'$, thus proving the angle $c' b' d'$, between the tangents, to be correct as constructed geometrically in the development in Fig. 56. This again proves the correctness of the development itself,

and therefore satisfies the demand for correct geometric basis in hand-rail construction.

The development in its folded position, as shown at $a\,b'c'o'$ in Fig. 57, forms the oblique plane of a sectional cut made through an assumed acute-angled block, the plan of which is shown at $o\,a\,b\,c$. This plan being identical with the plan of the stairway, it is evident that the development will be so also. From these considerations it follows that a wreath resting in the plane of this development will meet the conditions of its plan. This is plainly shown where the center line of the wreath extends from point a to point c' along the surface of the development, and

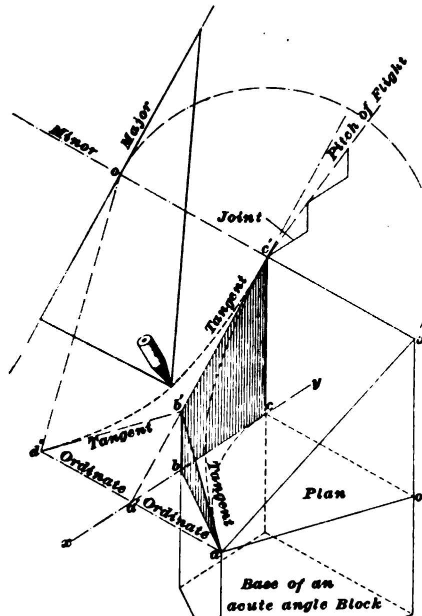


FIG. 57.

in a vertical position in relation to the center line of the wreath in the plan. If the face mold from Fig. 56 were placed in its proper position on the development in Fig. 57, the points a, b', and c in the latter figure would coincide with their corresponding points d', b', and c' in Fig. 56, and the angles between the tangents would also coincide.

Trusting that the preceding explanation will clearly demonstrate the why and the wherefore of each constructive line made use of to obtain the face mold and find the bevel, we will now turn our attention to Fig. 58. Before entering on our explanation we will remind the reader that, after the somewhat tedious explanation of the preceding diagrams, in actual practice the face mold and bevels can be found simply, as shown in this

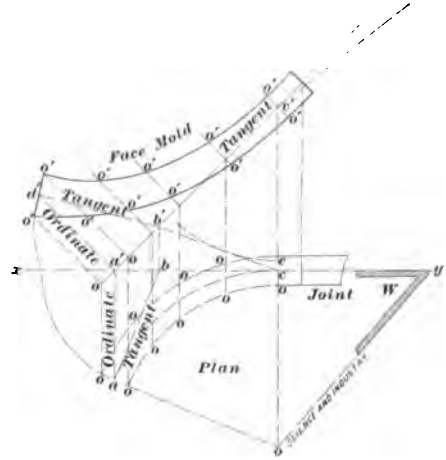


FIG. 58.

figure, and that a competent hand railer would not require a single line in addition to those it contains.

By comparing this figure with the preceding figures, it will be found to contain all the lines that are essentially necessary to find both the face mold and the bevels. Proceed with Fig. 58 by drawing the plan of the rail from the center o. Draw the ground line $x\,y$. Square to $x\,y$ draw $a\,a'$, and square to $o\,a$ draw the tangent $a\,b$. At c erect $c\,c'$, and make it equal in height to the sum of six risers, which is the number contained in the curve, as shown in Fig. 54, from a to f.

Connect c' to a', thus drawing the pitch of the upper tangent. Square to the pitch $a'c'$ draw $a'\,d'$, and make it equal in length

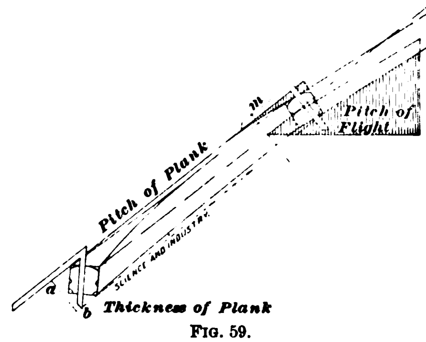


FIG. 59.

to $a\,a'$; connect d' to b', thus determining the angle between the tangents in the development, as was done in the preceding figures.

To find the curves of the face mold, proceed by drawing the ordinates $o\ o$, $o\ o$ on the plan parallel to the ordinate $a\ a'$ as shown, continuing all the ordinates to cut the pitch line. From points of intersection draw ordinates parallel to the ordinate $a'\ d'$, and make each equal in length to its corresponding ordinate on plan. We thus find the points o', o', etc. in both the inside and the outside curves of the face mold, and by tracing a curve touching the points thus found, the face mold is obtained.

The bevel is found, as in Figs. 55 and 56, by taking the point c' as a center, extending the compass to touch the line $b'\ c$, turning to e as shown. The length of $c'e$ will be the altitude, and the radius $o\ c$ of the plan the base of a right-angled triangle whose upper angle will be the bevel required as shown at W. It is to be applied to the bottom end of the wreath, as shown in Fig. 59, which is an illustration of the wreath squared out of the plank, the thickness of which is shown at $a\ b$. The bevel m in this figure is applied to the side of the wreath to make the joint coincide with the pitch of the straight rail. It is taken from Fig. 55, and then shown forming a square butt joint between the wreath and the straight rail connecting. The bevel n in Fig. 55 is also to be applied to the side of the wreath, to form a joint connecting with the newel.

THE END.

THE INTRODUCTION OF MORSE'S TELEGRAPH SYSTEM.

H. S. Webb.

A FEW notes concerning the introduction of the electric telegraph in this country by Samuel F. B. Morse may be interesting to our readers. Up to the introduction of his telegraph system, Morse was a portrait painter of more than ordinary ability, and depended on his work in this line for the money with which to develop his system and the construction of his apparatus. Not having enough money, he was obliged to surrender a quarter interest in his inventions in order to obtain the necessary aid.

The difficulties that Morse had to overcome in order to introduce his electric telegraph were serious and numerous. To be sure, he received encouragement when he exhibited his apparatus before the faculty of New York University, the Franklin Institute, and President Van Buren. The Franklin Institute recommended his system very highly, and expressed itself strongly in favor of government aid for the purpose of demonstrating the practical usefulness of the system. A bill appropriating $30,000 for the erection of an experimental line between Baltimore and Washington, to illustrate the general utility of the Morse system, was introduced in congress, but it was not passed until 1843, several congresses having met and adjourned without passing the bill.

First, a plow to be drawn by a team was devised and built, which would automatically deposit in the earth a lead pipe containing two insulated conductors. The use of India rubber and gutta percha for insulating was then unknown, and the insulation used was so poor that when ten miles had been laid the wires were found to be wholly useless for electric conductors. The machine itself was successful; but after $23,000 had been spent in an unsuccessful attempt to lay good conductors, the machine was purposely broken by running it against a rock, to forestall unfavorable criticism by the newspapers, which would have been the case had they known the true reason for the suspension of work. The newspapers published sensational accounts of the supposed accident, and thus the real trouble was kept from the public until new plans were developed.

After much careful consideration, Morse reluctantly decided to put the wires on poles. This plan was considered a very poor one at first, for fear that evil-minded persons would disturb the structure. But this was the only scheme for which the appropriation would hold out, and further, it had been ascertained that pole lines had already been adopted in England; this method was therefore employed. The line was completed about the first of May, 1844, and was successful, as the system proved satisfactory. Morse's first relay weighed 300 pounds, and when one weighing 75 pounds was produced, it was thought to be almost the height of perfection. The relay of today weighs about 3½ pounds.

A GREAT DISCOVERY.

(*Continued from the October, 1899, Number of "The Mechanic Arts Magazine."*)

George McC. Robson, M. A.

NEWTON ELECTED PROFESSOR OF MATHEMATICS—THE COMPOSITION OF LIGHT—CORRESPONDENCE WITH HOOKE—INDUCED BY HALLEY TO TAKE UP PROBLEM OF PLANETARY MOTIONS.

Admission to the sanctuary of science, and to the feelings and privileges of a votary, is only to be gained by one means—*sound and sufficient knowledge of mathematics, the great instrument of all exact inquiry, without which no man can ever make such advances in any of the higher departments of science as can entitle him to form an independent opinion on any subject of discussion within their range.*—SIR JOHN HERSCHEL.

On his return to Cambridge, in 1667, Newton was elected a fellow of his college, and was thus enabled to fix his residence permanently at the university. In the two succeeding years he rendered much assistance to Dr. Isaac Barrow, the Lucasian professor of mathematics; he revised and, indeed, largely rewrote Barrow's lectures on optics; he also, at the urgent request of Dr. Barrow, edited a translation of Kinckhuysen's algebra, but only consented to do so on condition that his name should not appear in the matter. In 1669, while discussing some recent mathematical discoveries with Dr. Barrow, Newton said he had obtained similar results some time before. Dr. Barrow communicated Newton's discoveries to several eminent mathematicians, who unanimously declared them to be very brilliant and important contributions to pure mathematics. Newton never published his discoveries voluntarily, and they remained unknown until some person, learning of them by accident, insisted on their publication; the discoveries of which we have just spoken would not have been made known then but for Dr. Barrow, and the method of fluxions was still unknown to the mathematical world. Yet, with all his reticence, Newton had already won such a reputation as a mathematician that Dr. Barrow, the same year, resigned his professorship in favor of Newton, who was elected to the chair and held it for thirty years.

To give the reader some idea of Newton's transcendent genius as a mathematician, we may mention his solutions of some of the problems mathematicians were then in the habit of proposing as challenges to each other. One of these was the historic problem of Pappus: to find the locus of a point such that the rectangle contained by its distances from two given straight lines shall be in a given ratio to the rectangle contained by its distances from two other given straight lines. Every celebrated geometer, from the time of Apollonius, had tried this problem and failed; it seems, however, to have presented no difficulty to Newton, who proved that the locus is a conic section. In 1696, John Bernoulli challenged the mathematicians of Europe: (1) to determine the line of quickest descent of a bead along a smooth wire from a fixed point A to another fixed point B, and (2) to find a curve such that if a straight line passing through a fixed point O cuts the curve in two points P and Q, then $OP^n + OQ^n$ shall be constant. Leibnitz admired the beauty of the first of these problems, and asked for an extension of the time allowed for its solution from six months to twelve; he solved the problem in a little over six months, and then suggested that the two problems should be sent to Newton. On January 29, 1697, Newton received the two problems from the President of the Royal Society, and handed the solutions to him the next day, at the same time generalizing the second problem. Bernoulli received solutions of the two problems from most of the eminent mathematicians of the day; but, though Newton's solution was anonymous, Bernoulli said he recognized it "as the lion is known by his claws." A curve of quickest descent is technically called a *brachistochrone*, and Newton showed that, under the conditions of Bernoulli's problem, the brachistochrone is part of a cycloid, which is the curve described by a point on the rim of a circular disk rolling on a straight line. In order to feel the pulse of the English analysts, Leibnitz, in 1716, proposed the problem of determining the orthogonal trajectory of a family of curves. Newton received the problem at 5 o'clock in the afternoon on his return home from an extremely fatiguing day in the Mint; within five hours he not only solved the problem proposed by Leibnitz, but laid down the general principles for finding trajectories. These achievements prove

that he was immeasurably superior to his contemporaries in his power of using both the methods of pure geometry and the methods of analysis. Indeed, his power of obtaining results by purely geometrical methods is a continual source of amazement to mathematicians. Lagrange says that pure geometry is a strong bow, but it is one that only a Newton can fully utilize, and that inferior mortals must have recourse to analytical methods to obtain results that Newton reached geometrically.

The Royal Society is the oldest and most distinguished scientific society that has maintained a continuous existence. It was originally founded by Wallis, Brouncker, Wren, and Boyle, who, as early as 1645, formed a society to which Boyle, in letters dated 1646, refers as the Indivisible, or Philosophical College. The formation of this society was due to the suggestion of Theodore Haak, a native of Germany; its meetings were held weekly in London, sometimes at Cheapside, and sometimes at Gresham College. During the civil war most of the members removed to Oxford; where Robert Hooke, then assistant in Boyle's laboratory, joined their meetings. Charles II, in 1662, after his restoration, incorporated the Royal Society of London under a Royal charter, which conferred upon the society certain privileges and authorities; these privileges were amplified in the subsequent charters of April 22, 1663, and April 8, 1669.

The Royal Society was a potent factor in urging Newton to complete his investigation of the law of gravitation, and to it we are largely indebted for the publication of Newton's Principia. We shall have frequent occasion to refer to his connection with the society, and to his association with the founders and other prominent members of it. Of the founders of the Royal Society, Wallis and Brouncker were very distinguished mathematicians who both contributed largely to the development of modern methods. Robert Boyle was the seventh son and fourteenth child of the Earl of Cork, and was born at Lismore, in Ireland; he was an eminent chemist and physicist, and is still remembered in connection with the law that bears his name, viz., if the temperature of a gas is constant, the product of its volume and pressure is constant.

Boyle was a voluminous author, and one of his works roused the ire of Dean Swift, who, to ridicule it, wrote, "A pious meditation upon a broomstick in the style of the honourable Mr. Boyle." Sir Christopher Wren was an able mathematician, and for several years was Savilian professor of astronomy at Oxford University. His fame as a mathematician and an astronomer is, however, completely overshadowed by his greater fame as an architect. After the disastrous fire that devastated London in 1666, Sir Christopher drew up a plan for a new city in which the streets were to intersect at right angles, as in modern American cities. Unfortunately, this plan did not meet with the approval of the king; yet the great fire gave him an opportunity of designing public and private edifices, such as no British architect has enjoyed before or since. Among the buildings erected from his plans were St. Paul's Cathedral, the Monument, the modern part of Hampton Court, and almost one hundred other public buildings and churches. In the routine of his architectural work he was assisted by Dr. Robert Hooke, who was a brilliant, though somewhat superficial speculator, and who possessed great experimental skill. Hooke's name is still associated with the law he discovered, which is that within certain limits the tension in a stretched string is proportional to the extension.

These were the men who laid the foundations of the Royal Society, and each of them is entitled to a place on the honor roll of science, though their fame is somewhat obscured by their proximity to Newton, as the brightest stars are invisible in the neighborhood of the midday sun.

During Newton's tenure of the Lucasian professorship, he lectured once a week during one term of each year. The lectures did not exceed one hour in length, and it is said he dictated them as rapidly as they could be taken down. After the lecture the students were accustomed to come to his room to discuss the lecture with him, and to receive additional explanations. His first lectures, which were on optics, were subsequently published both in Latin and in English, and are even now considered very valuable. During this period he invented the sextant, which is still used by navigators under the name of Hadley's sextant. This instrument has been called after Hadley, who rediscovered it in 1731, after Newton's death. Hooke had an idea of constructing a similar instrument, which is described and illustrated by a figure in his posthumous works; but as this instrument admits of only one reflection it would not answer its purpose. Newton sent a full description of his instrument, with drawings, to Dr. Edmund Halley, in

1700. Halley never made any public reference to this document, and nothing was known of it until it was found, after the Doctor's death, among his papers, by Mr. Jones, who communicated it to the Royal Society in 1742. Unfortunately, through confusion of the names Halley and Hadley, it has been asserted that Newton's description of the sextant was found among Hadley's papers at his death, and, therefore, he has been accused of knowingly stealing Newton's invention. But the whole evidence goes to show that Hadley made his invention independently. A similar instrument was also invented, in 1730, by Mr. Thomas Godfray, of Philadelphia, who received a grant of £200 from the Royal Society of London for his invention, which had already been practically tested by his brother, Captain Godfray, in the West Indies. The history of science abounds in such instances of important inventions and discoveries being made independently and simultaneously by men at the opposite ends of the earth.

All the telescopes in use at that time were what is known as refracting telescopes, and the image seen in a refractor was always more or less blurred and indistinct. The only remedy then known for this grave defect was to make the telescope glass very small and the focal length very great. Most of the refractors were so long that they had no tube, and were very inconvenient. By a very remarkable series of accidents it happened that Newton not only failed to correct the defect of the refracting telescope, but even imagined that his experiments proved it was impossible to remedy it. He abandoned, therefore, the attempt to construct a perfect refractor, and made a reflecting telescope on the same model as the one he had constructed in 1668. This type of telescope is known as a "Newtonian reflector." Newton communicated a description of his telescope to the Royal Society, and presented the instrument itself to the society, in whose library it is preserved with the inscription: "The first reflecting telescope, invented by Sir Isaac Newton, and made with his own hands."

The members of the Royal Society were so impressed with the value of this invention that they immediately elected him a fellow of the society. He was very much surprised at the value they placed on his invention, and their flattering reception of it led him to communicate to the society his theory of light and color. This theory was expounded in a paper addressed to the Royal Society under the title "A New Hypothesis Concerning Light and Color." In this paper he asserts that white light is not homogeneous, but consists of rays of different refrangibility, and he demonstrates his proposition by the celebrated experiment of the solar spectrum, in which a ray of white light is decomposed into a series of colored bands like a rainbow. Thus he laid the foundation of the science of optics and the modern theory of light, which today is declared by competent authorities to be the most important and promising department of physical investigation. The value of original scientific work is best measured by the number and extent of the new paths to knowledge and new fields for research which it opens up; and in this respect Newton's Optics is second only to his Principia.

There is no evidence that Newton's thoughts reverted to the subject of gravitation from 1666 to 1677; in the latter year he discussed it with Sir Christopher Wren, and explained his hypothesis as to the law of the inverse square. In 1679 Hooke wrote to Newton, urging him to continue his philosophical communications to the Royal Society. Newton protested that he had nothing to communicate worthy to be received by the society, and said that he had ceased to interest himself in philosophy, except as a diversion from other studies. In this letter he suggested that the earth's rotation on its axis might be proved by observing whether a bullet, falling freely, deviated in an easterly direction from the perpendicular. He proposed that Hooke should make the experiment, and suggested elaborate precautions for its success. In this letter Newton said that the path described by the bullet would be a spiral passing through the earth's center. This statement would be correct for a body moving in a resisting medium; but Newton was considering the case of a body falling freely, the resistance of the air being neglected, and his blunder in stating the path to be a spiral shows how little real thought he had given to the matter at that time. Hooke reported the success of the experiment, and stated that the bullet, on each trial, fell slightly to the southeast of the perpendicular; he also drew Newton's attention to his error with regard to the path of a falling body, and said the true path would be an "excentrical elliptoid." Subsequent writings of Hooke prove that by an excentrical elliptoid he meant an oval curve, and that he did not know that a body

falling freely would describe a true ellipse. The importance of this correspondence consists in the fact that it recalled Newton's attention to the question. At a later period Hooke claimed a considerable share of the credit for Newton's discoveries on the ground of this correspondence; but, beyond bringing the subject into prominence, Hooke's letters contain no helpful suggestions. Hooke attained such an unenviable notoriety for claiming other people's discoveries that he became widely known as the universal claimant.

In 1666, Newton did not enter at all into the mathematics of the problem, and made no attempt to obtain rigid demonstrations of the theorems he assumed; however, when his attention was recalled to the subject by Hooke, in 1679, he composed about a dozen propositions relating to the motion of the primary planets about the sun. What he had demonstrated at the end of 1679 may be summarized as follows: (1) The equable description of areas implies a central force, and conversely a central force implies the equable description of areas; (2) if an ellipse is described under the action of a force directed toward a focus, the force must vary inversely as the square of the distance. The converse of the latter of these propositions is that if a particle is projected under the action of a central force varying inversely as the square of the distance, the orbit described will be a conic section; but, at this time, Newton would have said the orbit will be an ellipse, for he had not yet considered parabolic or hyperbolic orbits.

In Hooke's letter of November 24, 1679, referred to above, he mentions the geodetic measurements then being made in France by Picard, De la Hire, Cassini, and Romer; and it is supposed that Newton obtained the result of Picard's measurement of a degree of latitude through his connection with the Royal Society. The statements on this point, however, are conflicting, and it does not appear possible now to determine when Newton obtained the correct measurement of the earth by which he revised his computation of 1666.

A decade and a half have elapsed since the fateful fall of the apple in the garden at Woolsthorpe, and yet the law of universal gravitation has not been discovered. Wren, Hooke, and many others are striving to solve the problem, and their failure is due to no lack of falling apples to inspire them, but simply to the fact that none of them possessed the necessary mathematical equipments. Newton, who alone possessed powers adequate to the task, was absorbed in other pursuits, and regarded this problem, however interesting and important, as something entirely aside from his special field of work. Fortunately, there was in England a man who could interest Newton in the problem and induce him to attempt its solution; and if we were asked how Newton came to discover the law of universal gravitation, we would reply that it was because Edmund Halley insisted that he should discover it, and he never rested till the discovery was made and published.

Dr. Edmund Halley, a most eminent mathematician and astronomer, was born near London, October 29, 1656. His father, a wealthy soap boiler, had him educated at St. Paul's School, and afterwards at Oxford University. In 1672, a year before he left St. Paul's School, Halley made valuable observations on the change of variation of the magnetic needle at London. In 1691, the Savilian professorship at Oxford being vacant, he applied for the chair, and Bishop Stillingfleet was desired to recommend him at Court. The bishop, hesitating to recommend him on account of his reputation as a skeptic, sent his chaplain, Bentley, to interview Halley; but he was so sincere in his opinions that he refused absolutely to profess any belief in the Christian religion. On this account Halley lost the appointment, which was given to David Gregory, who was strongly recommended by Newton. Halley is now best known in connection with the comet named after him; but his contributions to science were very numerous, and of the highest practical importance. He made two extended sea voyages, under difficulties that would have discouraged most men, to obtain data to complete his theory of the variation of the magnetic compass. On his return he invented and published a chart showing, at one view, the variation of the compass throughout the whole extent of the Atlantic Ocean. The method of chart construction invented by him is now extensively employed for a great variety of purposes; the maps published daily by the Weather Bureau are an admirable illustration of the simplicity and effectiveness of such charts.

Sir Christopher Wren, in 1684, offered as a prize to Hooke and Halley a book worth £2, if they would bring him, within two months, a proof that the orbit of a planet under a central force varying inversely as the square of the distance would be an

ellipse. For seven months they wrestled with this problem, but failed to solve it. Finally, in despair, Halley went to Cambridge to get Newton to assist him in the solution. Immediately on entering Newton's room he inquired, "What path will a particle describe if it is attracted by a center with a force varying inversely as the square of the distance?" Without hesitation Newton replied, "An ellipse." In amazement at this prompt and confident reply, Halley said, "How on earth do you know?" Newton said he had proved it some time before, and made an unsuccessful search for the paper. Later he found the paper and sent it to Halley, who submitted it to the Royal Society. The society requested permission to publish it, and appointed Halley to correspond with Newton and see to the publication of the paper.

Bitter controversies had arisen over Newton's Optics, which were exceedingly painful to his sensitive and modest nature, and his dread of these disputes induced him to withhold his great discoveries from publication; but Halley, recognizing the richness of the treasure he had found in Newton, spared neither his time nor his money in pressing Newton's researches to completion and publication. Having once consented to the publication of his results, Newton resolved to make them as complete as possible, and now at length, in 1684, he entered in earnest labors, which, by common consent of all who can appreciate the profundity of his far-reaching methods, have raised him to a solitary eminence in the world of science, and which have given us, in the law of universal gravitation, the grandest and completest generalization to which the mind of man has yet attained.

ERRATUM.—Readers of this article are requested to substitute "horizontal component of the tension in the string" for "horizontal component of gravity" in line 30, second column, page 405, and in line 10 from bottom, second column, page 406.

EUGENE FIELD.

THE world is always delighted to honor any one that has signally contributed to its progress or its enjoyment. It should be noted, however, that one's chances of being distinguished by the world's applause are very much greater if the work that makes one conspicuous has been done out in the open, with anxious millions for an audience. Herein lies the explanation of the fact that no military or naval hero is compelled to go for many years unrecognized and unrewarded. His honors follow close upon his achievement. He sails away for a brief time to some Trafalgar or Manila, and, returning, finds that he has "taught his name to half the globe."

If he is a great orator, a gifted singer, a consummate statesman, the glare of publicity in which he lives makes it impossible for him to conceal his eminence or to escape the adulation that it brings.

Far different is the fate of the quiet worker—the philanthropist, the scientist, whose benefactions must be wrought in the seclusion of the laboratory, the great thinker whose instinct is to escape the "madding crowd," the poet whose thought can move rhythmically only in the midst of solitude and silence. For such as these, many years must elapse—years filled with struggle, with alternate hope and despair, with privation suffering and obloquy sometimes—before the world discovers that it has been harboring unawares a genius.

Among the many of this class that are condemned to endure the "hope deferred that maketh the heart sick" was the gentle poet laureate of childhood and wifehood and motherhood, and of the affections that enrich and beautify the realm where child and wife and mother are paramount. To those that know of his life work—its refined beauty and sweetness that have charmed many thousands of readers all over the world—it seems very pathetic that a few of the friends that loved him before he withdrew into the infinite silence are striving to keep the gaunt wolf of hunger from the home where remain those that made the world beautiful and life dear to him.

These friends are not asking for charity, as may be seen from their advertisement on another page of this magazine. They offer at less than its value a beautifully illustrated volume of poems selected from his writings. This they may do only because the illustrations were made without charge by eminent artist friends of the dead poet. Every home, and especially every home of children, should contain the poems of Eugene Field.

TIMBER FOR BUILDING PURPOSES.

(Continued from the October, 1899, Number of "The Building Trades Magazine.")

S. Alan Sloan.

DESCRIPTION OF HARD WOODS—GENERAL QUALIFICATIONS THAT ARE NECESSARY FOR LUMBER TO BE CLASSED AS GOOD.

WHITE oak is the most important variety, and is in large demand in building operations. It has a hard, close grain, a yellowish-brown color, and possesses great strength and durability. Aside from these qualities, its great beauty of grain when rift- or quarter-sawed, and the high polish that may be imparted to and held by its surface, render it one of the most beautiful and adaptable materials for interior finish and fine cabinet work. When not rift-sawed, the grain presents a coarse, rough appearance, and is liable to discoloration from the entrance of dust and dirt in the exposed pores. The surface is often brashy, with short fibers, which break away easily; hence, stock of this character should only be used as framing material, for which purpose it is well adapted, owing to its strength and durability. It is, however, too costly to use in any but high-grade work.

The post oak is a tree that seldom attains a greater diameter than 15 inches, and on this account is used principally for posts, from which use it derives its name. It is considered stronger than white oak, and is very durable. Large forests of it are found throughout Maryland and Virginia.

The red oak resembles white oak very much in appearance, but has a reddish color, hence its name. It is inferior to the white oak, having about 12 per cent. less strength, and decays rapidly when exposed to dampness.

Live oak is a tree having a heavy, compact, fine-grained wood, yellowish in color. It is very strong and tough, and, therefore, is used in naval construction.

As a finishing material for the interior of buildings, chestnut has no equal when both appearance and cheapness are important considerations. The wood is comparatively soft, and has rather a coarse grain and no medullary rays. Its durability, which enables it to successfully resist the evil effects of moisture, renders it a useful material for purposes where this condition is encountered, as in the case of fence posts, sills, and sleepers in contact with the ground. The best stock is obtained from the trees that have reached fifty years of age. Prior to that time the vessels and ducts in the wood are large and filled with sap, which, when dried out, leaves large open pores that seriously affect the strength of the wood. Soon after the half-century mark is reached, however, the heart wood commences to decay, the tree declines, and the wood becomes worthless. The market is supplied with this timber from the forests in the eastern part of the United States.

Cherry is a wood that has many excellent qualifications, making it adaptable for use as a finishing material in buildings of all descriptions. This wood is moderately heavy, hard, and durable, the annual layers being wide and even, while the medullary rays are fine and close; being red, they impart to the surface of the wood a reddish-brown color. Owing to the susceptibility of the surface to a very fine polish, it is frequently used as a substitute for the more expensive and rare woods, which it resembles closely when stained. In fine cabinet work it is largely used as an imitation of mahogany, rosewood, and ebony.

Ash is not as popular a wood as it used to be and is now little used for building purposes. It resembles red oak somewhat in appearance, although it is much lighter in color. The grain is coarse and the medullary rays are not so well defined as those of the oak. It is also hard and tough, but after a few years' exposure decays rapidly, making it unfit for structural purposes. In cabinet work it is sometimes used as a cheap substitute for oak and makes an excellent material from which to manufacture oars, as its tough nature allows it to resist the sudden shocks and strains to which the latter implements are subjected.

Maple is a hard, strong, close-grained wood of a light yellow color and very silky. Quartered stock, when selected, makes a very fine flooring material and is in large demand for that purpose. There are two peculiar varieties of this wood that are used for decorative effects in woodwork and extensively in fine cabinet work. Owing to the beauty of their grain, they are commonly known as curly and bird's-eye maple. The

former has a pleasing, wavy grain, while the latter is marked with numerous small spots that somewhat resemble birds' eyes in appearance. Both of these species of maple attain this peculiarity of grain from the distortion of the fibers; hence, lack the strength of the straight-grained wood.

Owing to its lack of durability, maple is not well adapted for exterior work.

Hickory is of little practical use for building purposes, being very difficult to work on account of the extreme toughness and hardness of its fiber. Another serious defect in its nature is a susceptibility to the attacks of insects. The greatest demand for it comes from the carriage and wagon builders, who require a tough flexible wood, owing to the sudden strains and twists that many parts of vehicles are called upon to resist. It is a pleasing wood to the eye, having a well-marked even grain, with many medullary rays that show up well in a quarter-sawed plank.

The wood of the locust tree is remarkable chiefly for the peculiarity of its grain, which has a broad-striped appearance, due to the large size of the vessels that it contains. This timber is hard and durable, and is especially impervious to dampness, in consequence of which it is used chiefly for fence posts and floor sleepers, and for similar purposes, where the evil effects of moisture must be guarded against.

Walnut, mahogany, rosewood, and ebony are hard woods, all of which derive their value from the great beauty of their grain and coloring. They are used extensively in fine cabinet work. Mahogany, especially, is very popular, and is employed extensively for the interior finish and furniture of modern buildings. Walnut at one time was the most prominent of all the hard woods, but its scarcity and the superior beauty of mahogany have gradually caused the latter to take its place. The color of walnut is a deep, rich purplish brown, the grain is wavy, and the surface is capable of taking a beautiful polish. The tone of the wood improves with age, and in structure it is heavy, hard, and durable, being also proof against the attacks of insects. The demand for this wood in the past has been so great that the forests have become depleted to some extent, and it has become very expensive.

There are two varieties of mahogany, known commercially as Honduras and Spanish. The cheaper and more common of these is the Honduras, or bay wood, as it is often called; this has rather a plain coarse grain compared with the finer qualities of the Spanish mahogany, and some varieties of it are nearly as soft as white pine, making it very easy to work. This wood is remarkably free from defects, and warps but slightly. These qualities, together with its beautiful color and durability, make it very useful to cabinetmakers and patternmakers. This wood grows in tropical countries, and is chiefly imported from South America. Spanish mahogany is superior to the Honduras species, both in beauty of grain and in coloring. It is harder, heavier, and darker in color than that variety, and its pores are filled with a chalk-like substance. It is seldom used alone either for joinery or cabinet work, but a thin veneer is laid on a core, or backing, of some other less expensive wood. The name of this variety of mahogany is somewhat misleading, implying the field of production as being in Spain, whereas it is obtained from the West Indies, the bulk of it being shipped from San Domingo. In the selection of mahogany considerable judgment and experience must be exercised, as there is a great difference in the quality and appearance of wood even of the same species; thus, too much attention should not be paid to the commercial name of the wood, as a higher grade of Honduras mahogany is often superior in quality and grain to some of the more common kinds of the Spanish variety. Rosewood and ebony, while used to some extent in cabinet work, are not as popular as mahogany. Rosewood is used chiefly for fine furniture. It is a handsome wood, the color is dark red or brown, with strong markings of a deeper tint; the tone improves with age, and the wood is very fragrant. The principal use for ebony is in inlaid work, or in conjunction with some other wood of lighter color to which it forms a foil on account of the contrast, it being almost black. Ebony is very hard and has an exceedingly close fine grain.

In the choice and inspection of lumber, experience is to a certain extent essential, but a few hard-and-fast rules may be laid down, which, if followed, will lead to a selection of good material even by one with little experience. Summarized, these qualifications are: straight fibers; freedom from large, loose, or dead knots and shakes of every description; the wood should be sweet to the smell—a disagreeable smell betokens decay—and any chalky appearance of fiber is a sure sign of decomposition; when planed the surface should have a silky luster; the annual rings should be regular and the color uniform. In naturally colored timber, such

as mahogany, the darkest color indicates the most strength and durability. A good test of the soundness of any timber can be made by tapping it at one end with a hammer. If the timber be sound and the ear is placed close to the other end of it, the tapping will be heard distinctly. Small defects that would condemn soft wood should be overlooked in hard wood, as absolutely perfect material of the latter type is rare.

The woods that have been described allow the architect, carpenter, joiner, and cabinetmaker a broad field from which to select suitable material for their work, and by the judicious use of them, beautiful effects may be produced in the interior finish of their buildings without the loss of stability or permanency. There are numerous other woods that have not been mentioned, but little use is found for them in building construction or cabinetmaking; consequently, a description of them is unnecessary.

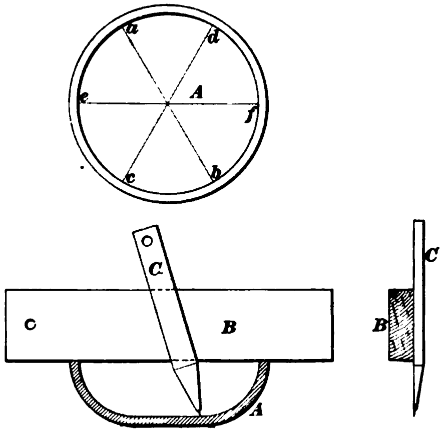
THE END.

TWO GOOD IDEAS.

A HANDY HOME-MADE MARKING TOOL FOR PATTERNMAKERS.

A. J. H., Peterboro, Ont., Can.

I EMPLOY in my pattern work for producing center lines across uneven surfaces of patterns (either concave or convex), a home-made tool, of which the following is a description, which may be of use to some of



your readers, and especially patternmakers. It is simple, and is quickly and cheaply made, and as opportunities to use it continually arise, it pays to make one, and to hang it on the peg as part of the outfit.

Suppose I have a pattern *A*, just taken off the lathe, and want to draw lines *a b*, *c d*, *e f* across the inside of the pattern; then I space off points *a*, *b*, *c*, *d*, *e*, *f* and use my tool, which consists of a straightedge *B*, made of a piece of wood 2 inches thick, 6 inches wide, and of suitable length, one side of which is faced and one edge squared up accurately, and a marker *C*, of wood, 2 inches wide, ¾ inch thick, and of sufficient length. This marker is pointed by chamfering down the edges and back, leaving the working side that is to go against the faced side of *B*, straight. For a marking point, I drive in a small wire nail, and file it so that the point is exactly even with the surface of the marker. The use of the tool is obvious.

A GENERAL INDEX TO MAGAZINE ARTICLES.

W. C. Williamson, Port Hope, Ont.

To KEEP track of the various articles of value that are constantly appearing in trade journals and other magazines, the writer has adopted the following system, which he has used for a number of years, and found very satisfactory: Procure a good, well-bound index book of foolscap, quarto size, having 200 or 300 pages. Do not buy a cheap, flimsy book, but one that will stand for a number of years, for the value of a book of this sort increases the more it is used. When an article appears in either a book or magazine that the reader thinks worth keeping track of, he should enter under the proper letter, in the index book, its title, and also where it is to be found. Thus, for instance, the article on "A Home-Made Bunsen Burner," which appeared in the August, 1899, number of "The Mechanic Arts Magazine," would be entered under the letter B as follows:

Bunsen Burner, A Home-Made. Mechanic Arts Mag., Vol. IV, Aug., 1899, p. 313.

By this method a general index is kept of all desirable articles, and it requires but a few minutes to find the one wanted. The index book is also useful for keeping extracts on various subjects taken from books and periodicals that are seen at public libraries and other places, but are not owned by the person himself.

CURRENT TOPICS.

Mrs. Frederic R. Honey.

The Recognition of Japan.

IT IS less than half a century since Commodore Perry, on behalf of the United States, signed the first treaty between Japan and the civilized powers of the Western world. In 1854 the island kingdom was remote and little known. Its shores were visited occasionally by stray ships, and a few of its products had been seen in Europe and America; but intercourse with other countries was not desired by the Japanese, and foreigners landed there at their peril. The treaty with the United States was speedily followed by similar treaties with other commercial nations; it was the opening wedge which made way for the entrance of modern civilization into Japan.

The reception accorded by Japan to Western ideas is a familiar story. All other oriental nations have looked with dislike on the manners and customs of "barbarian" visitors; they have resented the idea of change, and have adopted new methods by slow degrees, if at all. Japan, on the contrary, met the newcomers more than halfway. "I came, I saw, I conquered," said a Roman general, returning victorious from battle. Modern civilization needed only *to be seen* in order to win an easy victory in Japan.

Who can guess what ambitions were lying dormant in this remote kingdom; what half-conscious desires for power were gradually maturing in her, wakened into fuller life by rumors that may have reached her of the advantages gained from the forces at the disposal of the white races! These things are a mystery; but it is certain that with Commodore Perry's treaty the hour and the man had come; and Japan was ready to seize her opportunity. A generation had scarcely passed—how short a period in the history of a nation!—and Japanese students were to be found by the hundred in America and Europe; Japanese schools and colleges were making a bid for the services of rising men of science and of letters; Japanese institutions and customs were becoming modified; a navy was in process of creation; an army was drilled on a new system; a modern code of laws was constructed; experiments were made in parliamentary government; the financial methods of the white races had been adopted, involving, alas! a heavy national debt, for the tree of knowledge always bears the fruit of evil as well as of good.

The second generation is still in its youth, for the infants of 1854 are not yet old men; and the students of history who are accustomed to observe the slow progress of other oriental peoples watch Japan with almost incredulous wonder. At first the belief was freely expressed that the changes were spasmodic, abnormal; that the growth was too rapid to be healthy or enduring; that it was contrary to nature and experience that new ideas should be assimilated so quickly; that the advance was due to an imitative faculty rather than to an intelligent appreciation of modern methods; that there was only a veneer of civilization affecting the few; that the mass of the population was untouched, and the country would soon relapse into something very like its old condition.

Such remarks are not made now as frequently as they were twenty years ago. No doubt they are in part true. Japan has its strong conservative element, which resists and resents change. The opportunities of foreigners for observation have been limited, and have rarely extended beyond the limits of the few seaports in which such persons are allowed to reside; so travelers cannot well tell from their own knowledge what is the disposition of the country population towards the innovations which have taken place. But, judging by results, it is evident that those who are making the changes are the real leaders of the country, and the condition of Japan now—less than fifty years after she became known to the foreigner—proves that her growth is not an ephemeral thing, born and dying in a season. It is a force that must be reckoned with not only by Asia, her own continent, but by the whole world.

Fifty years ago Japan was a "geographical expression," according to the modern phrase. Today she is a nation which has been victorious in a great war with China, whose population is six times larger than her own; she has used her victory with such moderation that China is disposed to turn to her conqueror as a friend, and join hands with her

in resisting the pressure of the white races; she has induced Russia to withdraw from Korea, a province which Japan herself expects to control whenever the native government is superseded by a foreign power. Her progress in the practical applications of science is rapid. She has 3,000 miles of railway; her ships are in every port; her alliance is sought by countries which were powerful while she was unknown; her navy is larger than that of any other nation in the eastern Pacific, not excepting even that of Great Britain; and above all, she has at length established her claim to be received on equal terms by her sister nations, and to be treated by them in every respect as a civilized power.

This is the great event of the year 1899 in the history of Japan, and it may be that July 17th, the date on which it was consummated, will hereafter be regarded as an Independence Day. On that day treaties went into effect between Japan and the other civilized powers, superseding those which had been in force for varying periods during the past forty-five years. The French and Austrian treaties were concluded a few days later. For the first time in modern history the white races have placed a nation of another color and another religion on an equal footing with themselves; and, far from asking such concessions as a favor, the Japanese claimed them as a right. They consider that the advantages are not all on one side, by any means.

The new treaties give the freedom of the country to foreigners. Heretofore they could reside and trade only in certain specified treaty ports. If they desired to travel in the interior they had to have special permission, or else be really or nominally in the employ of a Japanese. This is now changed. The country is thrown open to all. Trade may be carried on in districts to which, as yet, the foreigner has scarcely penetrated, where the population is large, and the natural products are valuable. Here would seem to be fine openings for energy and capital. It remains to be seen whether Western competition will be welcome in the interior, where foreigners are less known than on the seaboard; and it is here that trouble is likely to arise unless care and caution are exercised on both sides. This free access to all parts of the country is the advantage offered to the white races in the execution of the new treaties.

In the eyes of the Western world the balance of gain is decidedly in favor of Japan, although the justice of her claim to be admitted to the sisterhood of civilized nations is recognized. She will be freed from disabilities which have been a source of continual irritation for many years, and for the first time she will be able to control her internal affairs with a free hand. Under the old treaties the Japanese government had no jurisdiction over foreigners who resided in her country. If a foreigner committed an offense he was not subject to Japanese law, but must be tried before the consular court representing his own country. Japan has treaty relations with sixteen foreign powers (not including China and Korea); therefore, in every treaty port there might be sixteen separate consular courts, each with a different set of laws, judging offenses according to different standards, often under the direction of a consul whose training had been in the counting house, and who had no legal education.

Under the new treaties this state of things has changed. Offenses of whatsoever kind and by whomsoever committed will be judged by Japanese courts, according to Japanese laws, and foreigners and natives will be subject to the same penalties. The new criminal code of Japan has been submitted to the examination of the treaty powers; their courts have been reformed; their new prison system is known to be conducted on humane and modern methods. Yet it is not wonderful that white races have hesitated before trusting their people to a system of justice so newly adopted, and which, as yet, can hardly be said to have passed the experimental stage. Schemes which look very well on paper do not always work well when put into practice. The spirit of the Japanese people, however, appears to command the confidence of the treaty powers. The government has given ample proof of its desire to advance. The people have cast off many of their old customs and have readily learned new ways. But the ways are still new, and Japan's conduct under these increased responsibilities will be watched with interest and with anxiety, while the almost inevitable defects in the working of the system will be sharply criticized.

Other changes involved in the new treaties are of great advantage to Japan. Heretofore, foreign residents have not been liable to taxation. Their property will now be assessed on the same scale as that of the Japanese themselves, and they will take their fair share in the support of the government under which they live. Japan will

also gain control of her own tariff. By the old treaties the import duties were fixed at a uniform rate, and they were very low, nominally only 5 per cent., and practically not more than 4 per cent.; while in foreign ports Japan has to pay duties on the large scale which usually prevails under a protective tariff. The Japanese have also long complained that foreigners benefit by the lights and buoys on her coast and by the harbor regulations, and yet contribute nothing towards the cost of their maintenance by means of harbor and tonnage dues.

Japan needs every penny on which she can lay her hands. Experiments in government are always costly, and her initial outlay in many directions has been heavy. The ordinary expenses of government would easily consume the whole amount produced by a moderate taxation of her people. The tax rate increases rapidly, and yet she cannot by any means live within her income. Her military expenses are enormous, consuming nearly two-thirds of her revenue, and this is a severe strain on the nation. The indemnity she received from China after the war of 1894–95 was all spent in Europe on naval and military material, and so determined is she to establish her supremacy in the East that she risks national bankruptcy rather than diminish her war expenditure. Her aim is to hold in the Pacific a position corresponding to that of Great Britain in the Western world.

Geographically, the circumstances of the two kingdoms—or empires—are very similar, with points in favor of Japan. The curved line of the Japanese islands extends from Kamchatka to the tropics, and throughout its whole length it is within easy reach of Asia, commanding the coast of China, one of the most populous countries in the world. Japan points to the position of Great Britain off the coast of a great continent as the original source of her commercial superiority, and sees in her own geographical situation the promise of corresponding success in the future. The Japanese, too, like other island peoples, are born sailors, and can make themselves at home in any climate. Protected by the seas which form their bulwark and the highway by which they are placed in communication with the whole world, they believe that a career like that of Great Britain may lie before them. Who knows whether the swing of the pendulum of Time may not be about to give to the Asiatic races their turn of superiority in the world's affairs?

Some of the friends of Japan think that her rulers are defeating their own destiny by making haste; that their prospects of becoming a great nation in the future would be better if they advanced more slowly, consolidating their national prosperity as they went, and making more coherent progress. It is hard for outsiders to tell whether the leaders are not moving too fast for the mass of the people, and risking the fate of the vanguard of an army which becomes separated from the supporting columns. But slow and sure methods of national advance are out of fashion for the present. The United States, and the British and Russian empires now take the lead amongst the nations, and each has advanced by leaps and bounds during the century which is now drawing to a close. If Japan effects the alliance with China for which she hopes, forming out of the Mongolian race one solid compact body of which her own progressive spirit shall be the brain, she is justified in expecting to accomplish great things in the near future.

LIQUID GAS AS A FIRE-EXTINGUISHER.

MR. GEORGE SPENCER recently read a paper before The Institution of Mining Engineers of London, in which he described the successful application of liquefied carbonic-acid gas to extinguish a fire in a mine with which he is connected. The fire was caused by the roof falling on the steam pipes. The heading was quickly built up and every effort was made to exclude the air, but sufficient air reached the fire to keep it burning. It was then resolved to try carbon dioxide, and six cylinders of the liquefied gas were applied, by which means the fire was completely extinguished. Mr. Spencer does not claim that this method can be successfully applied to all gob fires; but undoubtedly there are many cases that can be so treated. This method should prove invaluable in fires on shipboard and in warehouses, where much valuable merchandise is ordinarily destroyed by the water used to extinguish fires.

CHIPS & SPALLS.

An Exchange for Members of the Crafts.

***Readers are solicited** to send us any inquiries and statements of facts coming under their observation, which they desire to have discussed by their fellow workmen. Any rough pencil sketches, helpful to an explanation, will be touched up, if necessary, and presented in good form.*

Acceptable answers and descriptions of work, other than direct inquiries, will be paid for, when published, at our regular rates.

Communications intended for this department should be clearly addressed "C. and S." Editors of SCIENCE AND INDUSTRY, *Scranton, Pa.*

Write on one side of the paper only. Make sketches on separate sheets of paper. The name of the writer will appear in the magazine, unless otherwise requested.

ARCHITECTURAL LETTERING.

P. R. M., Omaha, Neb.

I ALWAYS look to the Chips and Spalls columns of "The Building Trades Magazine" for ingenious ideas and suggestive queries, and was struck by John Sterlinger's inquiry

about handy lettering for drawings, in the September issue. Being also a "pencil pusher," I am much interested in the matter myself, and perhaps my experience in this line may be valuable to him and other readers.

To begin with, nearly all of us are poor letterers by nature, and need a lot of practice that we do not get time for. To make my drawings look respectable, I use (when on my good behavior) the system shown in the sample which I send. As may be seen, the feature of this system is its liberal use of circles. One-third of the small alphabet, including the letters most used, and one-fifth of the capitals in this system, are founded upon the circle, and hence can be quickly drawn with the bow-pen. My practice is to sketch all the letters of a drawing roughly in pencil on guide lines, as shown, and then finish up freehand. I have found that accurately round letters, sprinkled liberally among imperfect angular ones, go a good way towards redeeming the character of the work.

WRITING ON STEEL.

Chemist.

I HERE submit to the readers of SCIENCE AND INDUSTRY a method by which I succeeded in putting my name and address on my steel square. This will, undoubtedly, be of value to many mechanics, especially apprentices, who are more or less annoyed by having their tools borrowed for some time, or even stolen. When we have loaned a tool to some workman, the real ownership of it is often lost sight of, and there is usually a dispute before you can regain your property. This, however, is avoided when your name, in full, is upon it. The way in which I succeeded in marking my steel square was as follows:

I took a glass bottle, partially filling it with vinegar, and placed in it enough table salt to make a strong solution. I then poured in enough blue vitriol to make the solution dark blue in color. Taking a piece of soap, I rubbed it over the steel square where I wished to engrave my name, and then with a nail I wrote my name and address. I then spread the solution over the spot, and when the outline of the name had changed to a dark-red color, I washed the soap off and found the solution had eaten into the steel and there was my name and address, in my own handwriting, indelibly engraved upon the hard steel. The cost of this solution was only a few cents, and I think any mechanic that is troubled by having his kit of tools depleted by those who borrow and seldom return, could possibly use this suggestion with advantage.

A HANDY OILSTONE AND NAIL SET.

W. H. D. Bogue, Chicago, Ill.

ACCEPT my thanks for the check you sent me for the good scheme published in a recent number of your magazine. I enclose two more ideas, which may be of use to my fellow craftsmen.

Fig. 1 shows an oilstone set in the side of a jack-plane so that its surface projects about ⅛ inch. The general appearance is shown in *A*, while *B* shows the stone in

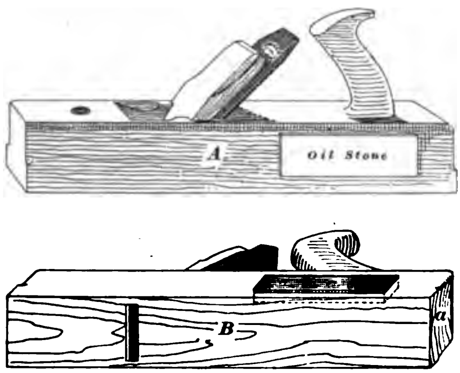


Fig. 1.

position for use. A carpenter will find this combination very handy. When he is on a high scaffold he doesn't have to come down to sharpen his plane, or run to his tool box at other times.

[Note.—As the workman needs oil to use his stone, and also to smooth up his saws, it would be a good idea if a hole were bored in the body of the plane, say at *a*, in which a cylindrical oil can, such as sold for bicycles, could be kept. The can could be kept in place by a leather flap, or by a revolving washer of any kind.—Ed.]

In Fig. 2 is shown a handy scheme for carrying a nail set. Few carpenters constantly carry a nail set; consequently, when they need one they use a nail, which either stings their fingers or flies past their ears with that *very* unpleasant hum we all know so well. Sketch *A*, Fig. 2, shows the punch in place. A leather washer *b* is fastened to the end of the handle, the hole in the washer being slightly smaller than the cross-section of the set. If a groove is filed around the set, it will assist in keeping it in place.

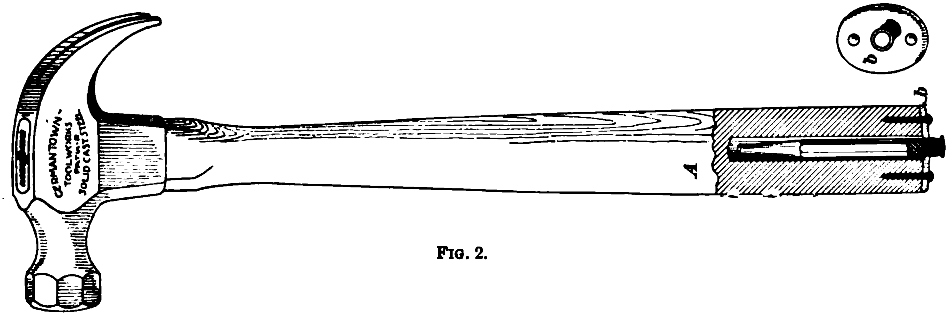


Fig. 2.

HEATING WATER FOR A LARGE BUILDING WITH WASTE HEAT.

J. G. Ould.

The writer gives the following description of a method that he used to make waste heat do useful work, in the hope that it may be of some help to others who may be asked to solve a similar problem. When installing the mechanical plant of a large building, among other things a hot-water heater was required to supply about 75 outlets for sinks and wash basins.

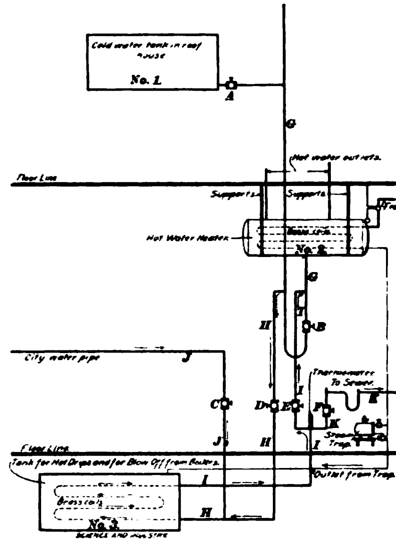
To do this work, a cylindrical tank No. 2 was made, and suspended from the ceiling of the boiler room. It was fitted with a brass heating coil, one end of which was connected with a live-steam pipe from boilers, the other to a trap, as shown in sketch, to take care of the water of condensation. The temperature of the water was controlled by a thermostat of the Johnson Heat Regulating Company's regular style. Water to supply the heater is taken from the storage tank No. 1 on the roof, to the bottom of the heater, where it comes in contact with the brass steam coil and is heated. The city will not allow boiling water to be thrown into the sewers; for this reason it was necessary to make provision for the cooling of water from drips, steam traps, etc., and the hot water from boilers when blown down, in order that it might enter the sewers at a safe temperature. For this purpose a large cylindrical closed tank was made, fitted with a brass coil, through which cold water could be passed, to cool the water in tank No. 3. The water from the tank is pumped into the sewer by an ordinary duplex steam pump, controlled automatically by a gravity governor. Having two opposite ends to attain, the idea suggested itself that it would be a good plan

to make them work together. This was carried out by means of the arrangement of piping as shown in sketch. All pipes, valves, etc., not in use in the actual scheme for heating and cooling, are purposely omitted from sketch, to prevent confusion.

The method of working the arrangement is as follows: To work the tanks together, open valves *A*, *D*, *E*, and close *B*, *C*, *F*; the water will now flow down pipe *G* to pipe *H* and through it to the coil in the drip tank, where it takes heat from the hot water in tank No. 3, and circulates in coil to pipe *I* to the portion of pipe *G* above the closed valve *B* into the heating tank No. 2, whence it flows to where it is needed in the house. A thermometer is inserted in pipe *I*, so that the temperature of the water can always be noted; it ranges in this case from 150° F. to 190° F., but is generally almost stationary at about 180° F.

If necessary to cool the water in drip tank No. 3 quickly, it can be done by closing valves *D* and *E*, opening valve *C* from city mains, and valve *F*, which will allow the water from the coils to pass through trap *K* into the sewer. Now open valve *B*, to allow the water from *G* to enter the heater No. 2 direct, and turn on steam to heater coil; it will then work without interfering with the other tank or its piping.

Where large quantities of hot water are needed, if the waste heat were not enough to give the required temperature, the scheme would still save considerable steam, the live-steam coil only working long enough to make up the difference between the incoming water to the heater and the temperature required. In this case, however, the apparatus has been working two years.



The steam coil has never been used since it was tried, when first put in. In this instance, we save at both ends, the steam and water—the water being metered and sold by the cubic foot.

TRADE NOTES.

Not all machinery is productive of gain directly; a good deal of it serves indirectly only—none the less effectively, however, by preventing loss. Of the latter kind is a machine that the makers choose to call an arbor press. We cannot but fully endorse the maker's claim as to the usefulness of such a contrivance in any shop, even if there is but a single lathe in it. A set of nicely turned and finished mandrels is almost as much part and parcel of a lathe as the main spindle itself; but, while no one would dream of belaboring the main spindle with a sledge hammer, the mandrels are unmercifully beaten, bruised, bent, and broken in the endeavor to drive them in or out of a piece of work. As mandrels cost money, and it takes time to fix them up again after a severe attack from the sledge hammer, it is evident that a contrivance designed to press mandrels in and out without injuring them will soon pay for itself. Such a contrivance is the arbor press, the mechanism of which is simple. These machines are made by Edwin E. Bartlett, Boston, Mass.

M. T. Richardson Co., 27 Park Place, New York, publishers of "The Amateur Sportsman," in order to increase the already large subscription list of that excellent journal, is offering as an inducement to new subscribers a sportsman's knife that is reliable in every respect. This knife, which is illustrated in our advertising columns, is an excellent article to have while on a hunting or fishing trip.

We have received from The Standard Tool Company, Cleveland, Ohio, a vest-pocket edition of their catalogue. Besides being a catalogue, it contains blank sheets of profile paper for notes and sketches, and useful matter for machinists.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the Magazine.*

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(250) Is it possible to make a practical storage battery to operate an 8- or 10-candlepower lamp on a bicycle? If so, would you please give me the directions how to make and use one? I would charge it from a 110-volt dynamo.

A. P., Emmerick, Germany.

ANS.—We know of no successful storage battery for a bicycle that will operate a lamp of this size. Such batteries have proved to be too heavy and have not been able to compete with the acetylene light. Small electric lamps for bicycles have been made which are operated by a small primary battery, usually of the dry type. The lamps operated by such batteries are, however, much smaller than 8 or 10 candlepower. We would advise you to write to Jas. G. Banon & Co., 24-30 Hudson Street, N. Y., or to The Ohio Electrical Specialty Manufacturing Company, Troy, Ohio.

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(251) I have a small ½-horsepower motor, the field magnets of which are wound with six layers of No. 18 double cotton-covered wire. The armature is of the shuttle type, wound with No. 15 wire. It is a shunt-wound machine, and is at present connected in series with fifteen lamps in parallel across a 110-volt circuit. (*a*) Can you inform me of a cheaper or a better method than connecting the motor in series with the lamps, as above? (*b*) Could more power be obtained by connecting the field in series? (*c*) Can you give me directions for making a battery suitable for running a small motor of this kind?

G. S. W., Madison, Me.

ANS.—(*a*) You might make a cheap resistance of iron wire which would answer the purpose as well as the lamps. Such a resistance would need to be of about 12 or 15 ohms. (*b*) A small motor wound as you have described should have its field connected in series with the armature when operated in series with the resistance. This should give you a stronger field when the motor is loaded, because all the current will flow through the field. The motor would tend to race if the load was thrown off altogether, with field and armature in series. (*c*) You would need a very large battery to supply ½ horsepower, and it would not, on the whole, be a satisfactory method of operation. The best type for this purpose would be a bichromate plunge battery. This consists of two carbon plates or series of carbon rods, between which is hung a zinc plate that can be lifted out of the solution when the battery is not in use. The solution is made up of 3 parts of potassium bichromate dissolved in 18 parts of water, to which is added 4 parts of sulphuric acid. All parts given are by weight.

***

(252) Please send solution to the following problem: In the accompanying diagram (Fig. 1) the two circles O and P intersect at A and B. If the area of the circle O is 5 times the area included between the arcs APB and ACB, how is the radius PC found?

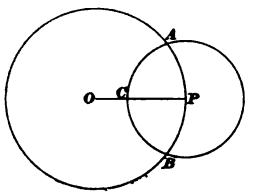

FIG. 1.

C. T., Belleville, Ill.

ANS. — In order to solve this problem, the radius R of the circle O must be known. Let the required radius $PC = PB$ be denoted by R_1. Then, by drawing the lines shown in Fig. 2, we have: Area $APBC$ = sector $AOBP$ − triangle AOB + sector $PACB$ − triangle PAB $= \frac{1}{2} R^2 \times 2x - \frac{1}{2} R^2 \sin 2x + \frac{1}{2} R_1^2 \times 2x' - \frac{1}{2} R_1^2 \sin 2x'$ $= R^2 (x - \sin x \cos x) + R_1^2 (x' - \frac{1}{2} \sin 2x')$. Now,

$$R_1^2 = (2 R \sin \tfrac{1}{2} x)^2 = 2 R^2 (1 - \cos x);\ x' = \frac{\pi - x}{2}.$$

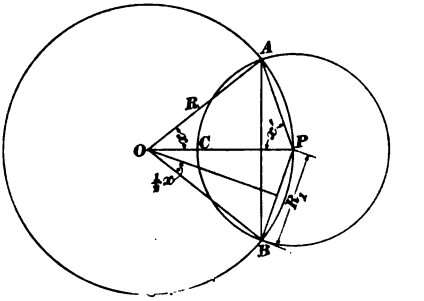

FIG. 2.

Substituting above, and putting result $= \frac{1}{5} \pi R^2$, we get

$$R^2 (x - \sin x \cos x) + 2 R^2 (1 - \cos x) \left(\frac{\pi - x}{2} - \tfrac{1}{2} \sin x\right) = \frac{\pi R^2}{5},$$

which is easily transformed into

$$(\pi - x) \cos x + \sin x - \tfrac{4}{5} \pi = 0.$$

Solving this equation by one of the methods of successive approximations, the value of x can be found to any desired degree of accuracy. By using Newton's method, we have found x (degrees) = 39° 54′ 12″. The value of R_1 is $2 R \sin \frac{1}{2} x$, that is, $2 R \sin 19° 57′ 6″$.

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(253) (*a*) What is the easiest and best way to determine the size of main feed and main return pipe for a steam-heating system? I want a quick and economical method. (*b*) I have eight radiators, containing 84 feet of heating surface each. It requires

a $1\frac{1}{4}$-inch pipe to feed each radiator. Give the size of main steam and main return for the system.
G. D., Jackson, Tenn.

ANS.—(*a*) The quickest method of determining the sizes of steam pipes, radiators, or boilers, or any other part of a steam-heating system, is by means of charts, and we would therefore advise you to secure them. You can procure a set of four charts, all bound together, in one double folder. They are sold by The Technical Supply Company, Scranton, Pa., for $1.00 per set. All who figure radiation, or in any way proportion steam-heating systems, should be provided with a scientific chart. (*b*) You may start off with a $2\frac{1}{2}$-inch steam main, and come back with a 2-inch return main if your system is of the ordinary kind.

* * *

(254) We have a 120-gallon galvanized-steel cylindrical range tank which burst around the bottom when used as a pressure boiler in the kitchen. We cut the bottom out, turned the tank upside down, and connected with range by $1\frac{1}{4}$-inch pipe, and used it as an open tank. It now makes so much noise, pounding, that unless remedied it will have to be taken out. The connecting pipes are level; the boiler is 2 feet from the opening in the waterback; the lower pipe is 3 inches from the bottom of boiler, and the top one is 6 inches higher; the boiler is 24 inches in diameter, and about 5 feet high. Can you suggest a remedy for the pounding?
O. G. C., Grand Junction, Colo.

ANS.—Place the upper pipe higher, say about midway in the height of the boiler.

* * *

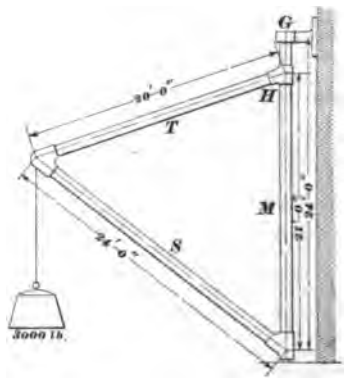
(255) Kindly give me your opinion and a remedy, if there is one, for the condensation of natural-gas vapors in brick flues. For several winters past a certain church in this city that is heated by a hot-water heating system, having natural gas for fuel, has had considerable trouble caused by condensation in the flues, ice being formed on top during exceedingly cold weather. The condensation was so great as to wet the brickwork and damage the walls of the building. The flue is 13 inches square and about 50 feet high. A 6-inch galvanized-iron pipe was placed inside the flue. full height, leaving the bottom and the top of the flue, around the pipe, open to the atmosphere, believing that the warm air rising from the cellar would keep the inner tube warm and thus prevent the condensation, but it did not, for the inner pipe froze just the same, ice forming in such large quantities on top of the flue that it became dangerous to pass beneath it. Three different makes of burners have been used in the furnace and have all seemed to work in the same way. It has been suggested that if the furnace were arranged to burn a quantity of coal with the gas, the surplus heat from the coal would keep the flue warm, and the gas would escape. I would be pleased to have any suggestion that will overcome the difficulty.
S. W. M., Pittsburg, Pa.

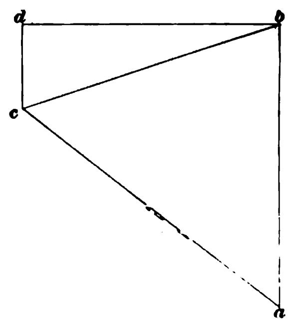
ANS.—The cause of your trouble is watery vapor, a product of the combustion of gas that is given off by all gas flames. We cannot think of any suitable means of removing that vapor from the other products of combustion before they enter the chimney except a condenser to condense it, or chemicals to absorb it. The condenser, however, would require a fan placed in the flue to give a draft to the chimney, because then the products of combustion would be cooled as low as that of the atmosphere and consequently would not produce a natural draft. Since we cannot remove the moisture satisfactorily without the installation of mechanism, it would appear that the best plan is to neutralize the evil effects of that moisture as much as possible while it flows up the chimney, and this can best be done by the application of dry air. It seems to us that if you ventilate your cellar through the chimney and thus have a current of air passing through, and then discharge the products of combustion from the heater into this current of air, a few feet above the bottom opening of the chimney, or any point convenient for the heater, the products will then mix with the air and become so diluted as to condense but very little on the sides of the chimney. The air, therefore, will act as an absorbent and carry the moisture with it. Judging from the rapidity with which the vapor condenses and from the rapid formation of ice on top of the flue, we are led to suppose that your chimney is built in a very cold place, and stands isolated and exposed to cold winds. If it were built in a warm place you would not be troubled so much.

* * *

(256) If a load of 3,000 pounds is suspended from crane as shown in enclosed sketch, what is the stress (*a*) in the strut *S*? (*b*) in the tie-rod *T*? (*c*) What is the horizontal pressure against the top support *G*? Please show how these can be worked out by the parallelogram of forces.
J. C., Sheffield, Mo.

ANS.—(*a*, *b*, and *c*) The stresses in the members of the crane may be determined by drawing a stress diagram, which is constructed as follows: The vertical line ab is drawn to scale equal to the vertical load of 3,000 pounds; bc and ca are then drawn parallel





to the members *T* and *S*, respectively, and bd and cd are drawn parallel, respectively, to the horizontal component *H* and the vertical member *M*. By measuring to the scale used, each line representing a stress, the stresses in the members of the crane are found to be as follows:

Stress in the tie *T*	$= bc =$	2,860 lb.
Stress in the strut *S*	$= ac =$	3,430 lb.
Stress in the mast *M*	$= cd =$	900 lb.
Horizontal reaction at foot of mast	$= bd =$	2,710 lb.
Vertical reaction at foot of mast	$= ab =$	3,000 lb.
Horizontal reaction *H*	$= bd =$	2,710 lb.

The horizontal reaction at *G* is applied 24 feet above the foot of the mast, instead of 21 feet; hence, this horizontal reaction is equal to $\frac{2{,}710 \times 21}{24} = 2{,}370$

pounds. At joint H there is also a bending moment in the vertical member M equal to $2,370 \times 36 = 85,320$ inch-pounds. This bending moment can be reduced by placing the reaction G and the joint H nearer to each other.

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(257) Can you give me the names and cost of some good books on economic geology and the metallurgy of the more important American metals (excluding iron); i. e., gold, silver, lead, and zinc?

H. M. K., McKee, N. C.

ANS.—As works on economic geology we can recommend "A Treatise on Ore Deposits," by J. A. Phillips, price \$10.00; "Ore Deposits of the United States," by Kemp, price \$4.00. As works on metallurgy we can recommend the following: For copper, "Modern Copper Smelting," by Peters, price \$5.00. For lead, "Metallurgy of Lead," by Hoffman, price \$6.00. For gold, "Metallurgy of Gold," by Eissler, price \$5.00; "Metallurgy of Gold," by T. A. Rose, price \$6.00; or, better still, a series of articles on metallurgy, written by H. Van F. Furman, and published in "Mines and Minerals." On silver, "Metallurgy of Silver," by Eissler, price \$4.00. The best thing that has been published on the metallurgy of zinc will be found in Vols. VI and VII of the Missouri Geological Survey, and a good article on the metallurgy of copper will be found in a pamphlet entitled "Mineralogy of Copper," by Henry M. Howe, which is published by the United States Geological Survey. As a book on metallurgy in general, giving the principal treatment of all the metals, we can recommend "Elements of Metallurgy," by J. A. Phillips, price \$9.00. Any of the above books can be obtained from The Technical Supply Company, Scranton, Pa., with the exception of the Missouri Geological Reports, which can be obtained by writing to the Geological Survey of Missouri, and the United States Geological Reports, which can be obtained by writing to Washington, D. C. The copies of "Mines and Minerals" can also be obtained by writing to "Mines and Minerals," Scranton, Pa.

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(258) (*a*) Is it possible to cut a gear of 53 teeth with a dividing head in which 40 turns of the worm cause one revolution of the disk? I have only one disk, with nine circles of holes on each side, as follows: On one side: 18, 24, 28, 30, 34, 37, 38, 39, 41. On other side: 66, 62, 58, 54, 49, 47, 46, 43, 42. (*b*) Is it possible to cut any prime number of teeth by compound indexing, outside of the prime numbers on the disk? (*c*) Can I cut any prime number not on disk, by triple indexing, that is, by using three circles of holes? (*d*) How can 81 teeth be cut?

R. L., Chicago, Ill.

ANS.—(*a* and *b*) The method of compound indexing is explained in "Home Study Magazine," March, 1898, Answers to Inquiries, No. 53; it is there shown why it is impossible to cut any prime number not on the disk. However, though it is impossible to cut with mathematical exactness any prime number not on the disk, yet it can be done with sufficient exactness for practical purposes. For example, we can cut 53 teeth by taking $\frac{7}{66} + \frac{24}{37}$ for each tooth; that is, by going 7 holes on the 66 circle, and 24 holes on the 87 circle for each tooth. The error in this approximation is estimated as follows: For each tooth, the dividing shaft makes $\frac{7}{66} + \frac{24}{37}$ of a revolution; therefore, the disk makes $\frac{1}{40}(\frac{7}{66} + \frac{24}{37})$ of a revolution; and for 53 teeth, the disk makes $\frac{53}{40}(\frac{7}{66} + \frac{24}{37}) = .9999897$ of a revolution instead of 1 complete revolution, the error being $1 - .9999897 = .0000103$. The last tooth, therefore, would be .0000103 of the circumference too large. If the diametral pitch is 1, the circumference is nearly 166 inches; and the error in the last tooth is $.0000103 \times 166 = .0017$ inch. For any other pitch the error must be divided by the diametral pitch; thus, for 53 teeth of 6 pitch, the error in the last tooth is $.0017 \div 6 = .0003$ inch, nearly. We may also cut 53 teeth by taking $6\frac{43}{47} - \frac{6}{49}$ for each cut; that is, by giving the dividing shaft 6 complete revolutions, then going 43 holes on the 47 circle, and going back 6 holes on the 49 circle. By this method the teeth are not cut consecutively, and we have to go 9 times round the disk before the 53 teeth are cut. When the diametral pitch is 1, the error in the last cut is .0066; to find the error for any other pitch, we divide this error by the diametral piteh. (*c*) Triple indexing will not enable us to cut any prime number not on the disk with mathematical exactness, but affords greater choice of ways of cutting the teeth approximately. (*d*) To cut 81 teeth take $5\frac{5}{41} - \frac{9}{49}$; that is, 5 complete turns, 5 holes on the 41 circle, and backward 9 holes on the 49 circle. To cut the 81 teeth, we have to go 10 times round the disk.

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(259) We have a flush closet in our house, of the usual kind. It is operated by pulling a chain and so opening the valve, but sometimes it flushes of its own accord, without the chain being pulled. What is the cause, and what is the remedy?

A. G. S., Milwaukee, Wis.

ANS.—The reason why your water-closet tank flushes of its own accord is that the ball-cock leaks water into the tank all the time, and in such a quantity as to overflow the tank and start the siphon. The remedy is to repair the leak. Perhaps the ball-cock just requires a new washer.

***

(260) (*a*) Kindly give me the recipe for Roman flux gold used for china painting, and also one or two other gold paints used for the above purpose. (*b*) What do you consider a good work on china painting, and where can I obtain it?

A. Z., Elkhorn, Mont.

ANS.—(*a*) Roman gold, also known as matt gold, burnish gold, dead gold, etc., is prepared by mixing pure powdered gold with oil of turpentine as a medium, and anhydrous borax as a flux. Metallic gold is dissolved in aqua regia, and then precipitated in the form of a fine brown powder by the addition of potash or green vitriol. This powder is thoroughly washed in distilled water and carefully dried, after which it is rubbed on a slab with borax and oil of turpentine. When this is applied to china, and the latter is "fired," the oil evaporates and the borax unites the gold to the glaze of the ware. The same result may be attained by executing the design on the china with borax and oil of turpentine, and then laying gold leaf on the sticky outline. (*b*) A good book on china painting is "A Manual for China Painters," by Mrs. N. Monachesi. It may be obtained from The Technical Supply Company, Scranton, Pa.; price, \$1.25.

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(261) (*a*) I wish to build and place a hot-air furnace in a 6-room frame dwelling. How can I arrange for good ventilation in winter, without exposing the inmates to cold drafts? Two of the rooms will have flues and fireplaces, for use when the furnace is not running; will these flues produce enough ventilation for these rooms? (*b*) Is it good policy to have water near the furnace, and in the rooms as well, for keeping the air moist, or is water at the furnace alone sufficient? (*c*) I intend to nail a board lining on studding, then paper and weather boards; is there any danger of the paper becoming damp and making the house damp? (*d*) To cleanse the pipe in the kitchen sink, what shall I pour down it?

L. M., Dayton, Ohio.

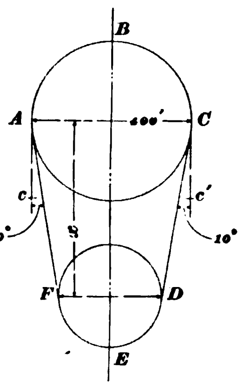
ANS.—(*a*) It is customary to depend on the ventilation naturally obtained from a hot-air furnace-heating system for an ordinary 6-room frame dwelling, without introducing special inlets independent

of the furnace-heating system. The open fireplaces as a rule produce sufficient ventilation for the rooms in which they are placed. (*b*) It is well to have a pan of water standing in the room to act as a humidifier, for the pan in the furnace is usually so located that the water does not evaporate quickly enough to produce the desired humidity before the air enters the rooms. (*c*) If you are careful in putting on the weather boards, there should be no danger of the paper becoming damp. Put on the clapboards weather-tight, and arrange the joints so that the rain will fall and wash clear of the crevices. (*d*) Pour hot lye down the pipe, or place a handful of washing soda in the sink and pour boiling water over it. Either of these should cleanse the pipe.

***

(262) In the figure, the perimeter $ABCDEFA$ is ½ mile, the diameter of the larger circle is 400 feet, and the angles c and c' are 10°. Find the distance x and the diameter of the larger circle.

O. C. G., Hobbs, Ind.



ANS.—Denoting the radius of the smaller circle by r, the unknown quantities x and r are obtained from the following equations:

$$r = 200 - \tan 10°;$$

$$x \sec 10° + \frac{80}{180}\pi r = \frac{2{,}640 - \left(400 \times \pi \times \frac{200}{360}\right)}{2}.$$

The solutions of these equations gives $x = 899.21$ feet, and $r = 41.44$ feet; whence the diameter of the smaller circle is 82.88 feet.

***

(263) (*a*) What is the chemical composition of the gasoline used in gasoline engines; is it made artificially, or is it a mineral oil? (*b*) What is petroleum, and where is it found? What is the difference between petroleum and kerosene?

A. L. L., Anneta, Tex.

ANS.—(*a*) Gasoline is one of the products of the fractional distillation of crude petroleum; it is composed of carbon and hydrogen, mainly of hexane C_6H_{14}, and distils over at about 60° C. (*b*) Petroleum is the crude mineral oil which is found in Pennsylvania, Ohio, California, Canada, Russia, Germany, etc. Kerosene is a second product of the distillation of petroleum; it distils over at from 150° to 300° C.

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(264) In the August number of "The Mechanic Arts Magazine" I notice an article on burglar-alarm wiring. I see by the cut that in the closed circuit there is a switch S, which, when closed, keeps the bell circuit open. If the circuit is shut off in the daytime by means of the switch S, would you not get a continuous ring from the bell, and would it not be necessary to have a switch in the circuit from B to A?

H. V. D., Lowell, Mass.

ANS.—Yes; it would be necessary to have some means for disconnecting the local battery circuit. This could be done by placing a small switch similar to S in the circuit leading from B to the bell.

***

(265) Why are teeth for spur wheels sometimes made involute and sometimes cycloidal in form? What is the difference between the two forms? What are the principal dimensions of the cycloidal? What is the best book you know of on the construction of gear-teeth? R. K., Sharon, Pa.

ANS.—We advise you to get a copy of George B. Grant's book on gear-teeth; write to him; his address is Lexington, Mass. Your questions show that you do not know much about gear-teeth, and it would be useless trying to explain to you why the involute is better than the cycloidal, without first explaining why the shape of a gear-tooth is such an important matter, and what the different shapes are; this would fill a book, and the best book we know of is Grant's.

***

(266) (*a*) Required the weight on the end of a safety-valve lever with the following data: steam pressure, 85 pounds; diameter of valve, 4 inches; length of lever, 33 inches; distance from fulcrum to center of valve, 1 inch; weight of lever, 8 pounds; distance from fulcrum to center-of-gravity valve, 13 inches. (*b*) What is meant by the following words: *data, fulcrum, gravity?* (*c*) Please describe the steam-engine indicator and explain its use.

F. E. P., Bucyrus, Ohio.

ANS.—(*a*) The area of the valve is 12.5759 inches. Neglecting the weight of the valve itself, which is not given, the weight required on the ends of the lever is

$$W = \frac{12.57 \times 85 \times 1 - 8 \times 13}{33} = 29.22 \text{ lb.}$$

(*b*) *Data* are facts or quantities supposed to be given or known in order to solve a problem or reach a conclusion. A *fulcrum* is the support on or against which a lever rests, or the point or pivot about which it turns. *Gravity* is the accelerating tendency of bodies towards the center of the earth, or, more widely, the similar tendency towards the center of any heavenly body.—*Standard Dictionary*. (*c*) The indicator consists essentially of a cylinder containing a piston of about ½ square inch area, the under side of which is subjected to the pressure of the steam in the engine cylinder. Above the piston is a spring which is compressed as the piston rises. As the pressure in the engine cylinder varies, the piston of the indicator moves up or down; this motion is magnified by a lever and is recorded on a strip of paper wrapped around a drum. A cord or wire wound around the base of the drum is pulled to and fro by the crosshead, or by a reducing motion attached to the crosshead. The diagram obtained is used to compute the horsepower of the engine, and is sometimes used to correct faults in valve setting.

***

(267) Where can I get a good side-view picture or scale drawing of a modern locomotive, such as is used on the New York Central Railroad?

G. G. C., Rowayton, Conn.

ANS.—You might write to the officials of some of the railroads or to some locomotive works; we cannot say whether you would get what you want or not. About the best thing you could do, supposing the above were to fail, would be to buy "Modern Locomotives," price $7.00. This gives working drawings of all the representative locomotives, American and European. The Technical Supply Company, Scranton, Pa., can forward it to you postpaid for the price named.

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(268) (*a*) Theoretically, how many B. T. U. does it take to develop 1 horsepower? (*b*) Theoretically, how many horsepower will 1 pound of coal develop, assuming that the quantity of heat contained by the coal is 14,000 B. T. U. per pound? Kindly give the figuring used to solve these questions.

P. M. S., Putney, Vt.

ANS.—(*a*) To give this question any definite meaning, the time must be taken into consideration. Thus, a horsepower is defined as the production of 550 foot-pounds of work per second, 33,000 foot-pounds per minute, or 1,980,000 foot-pounds per hour, etc. The mechanical equivalent of 1 B. T. U. is

778 foot-pounds; therefore, theoretically, it requires $\frac{33000}{778} = 42.42$ B. T. U. per minute, or $\frac{1980000}{778} = 2.545$ B. T. U. per hour to develop 1 horsepower. (*b*) Reducing the 14,000 B. T. U. to the equivalent mechanical work, we obtain $14,000 \times 778 = 10,892,000$ foot-pounds. The burning of 1 pound of this coal, provided all the heat energy is changed to work, will give

$$\frac{10,892,000}{1,980,000} = 5.5 \text{ horsepower per hour.}$$

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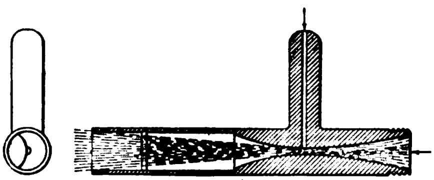
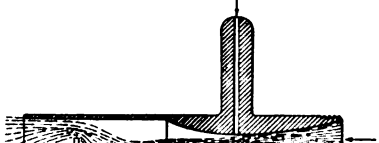
(269) I have an aspirator, and near the discharge end of the tube is placed a small obstructing plate, which reduces the area just one-half [see Fig. (*a*)]. The apparatus does not work nearly as well without this plate. (*a*) What is the function of this plate? (*b*) Can you tell me what the relative areas of the contracted water pipe and air-inlet pipe should be? (*c*) Why is the water pipe drawn to a knife edge at the inlet and not at the outlet end? (*d*) Is a certain curve required in the contracted portion? (*e*) Can you give me any formula for calculating the number of pounds of gas delivered, when it is taken in at a known pressure and discharged against a greater pressure, the velocity of liquid employed being known? (*f*) Can you tell me of a book on the subject? V. J. G., New York, N. Y.

ANS.—(*a*) The action of the apparatus depends on a partial vacuum being formed in front of the air tube where it meets the water tube. For the purpose, a chamber must be provided, and the insertion of



(*a*)



(*b*)

the plate so deflects the stream of water that such a chamber is formed as indicated in (*b*). (*c*) A knife edge at the discharge end would throw the vacuum chamber farther out, while it would not serve to decrease the resistance to the flow here as it does at the inlet end. (*d*) We do not know about any theory on the curvature of the contracted portion of the pipe; in many similar apparatus it has simply the shape of a double cone. (*b*, *e*, and *f*) Theory gives but little satisfaction with these apparatus. We refer you for same to "Weisbach, Ingenieur-Mechanik," Part III, Section 2. The efficiency of the arrangement is known to be very low, not over .15; so that

$$E = .15 = \frac{Q_1}{Q}\frac{h_1}{h},$$

where

Q = weight of water used per second in pounds;
Q_1 = weight of air transferred per second in pounds;
h = head of water in feet;
h_1 = pressure against which air is delivered, expressed in feet of water.

***

(270) I have a piece of work on hand in galvanized wrought-iron drainage, in which the pipes are screwed together. In almost every case the joints leak, though screwed up tight with tongs. The inspector in charge will not permit the use of any packing material at the joints, but orders them to be screwed together as they come from the pipe shop. In order to conform with the law, the pipes will have to be tested with water under a head of 60 feet, without leaking. I had thought of filling the pipes with some mixture that would rust the joints, and so prevent their leaking. Would salt water do this, or is there some material that would serve the purpose better? No outside cements will be permitted. In all, there are about 5,000 joints.
W. C. O., Brooklyn, N. Y.

ANS.—The inspector you refer to does not know what he is talking about when he prevents you from using cement on the threads of your drainage system, as the cement protects the iron, and if any of the threads are exposed at the couplings, it protects that part from corrosion. It is evident that he never screwed two pieces of 4-inch pipe together in his life, or he would not be so stubborn in your case. We do not advise the use of a mixture of anything that will rust the joints tight by filling the drainage system with the liquid, for by so doing you tend to ruin the inner surface of the drainage system. If you must rust up these leaks, then seal the drainage system, make a vacuum in it, and apply a solution of sal ammoniac and water with a brush to the outside of the threads.

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(271) With reference to the gasoline engine that was described in the January number of "The Mechanic Arts Magazine," can you give me the dimensions of a 6-horsepower engine of the same type? I wish to build one for my boat. R. D., Fall River, Mass.

ANS.—The following are leading dimensions; we cannot of course give design of small details:

Revolutions per minute	280.
Diameter of cylinder	$6\frac{1}{4}$ inches.
Stroke	8 inches.
Diameter of exhaust port	$2\frac{3}{8}$ inches.
Diameter of inlet port	$2\frac{1}{4}$ inches.

***

(272) (*a*) Is there any rule whereby the cube can be doubled? If so, how? (*b*) Is there any rule to square a circle? If so, please give it. (*c*) What is the best book on the air brake, and where can it be obtained? (*d*) How can I make a microscope of high power, and where can I obtain the lenses? (*e*) Name a book on optics. H. S., Saxton, Pa.

ANS.—(*a* and *b*) There is no mathematically exact method. (*c*) The Instruction Papers on this subject published by The International Correspondence Schools. (*d*) You can obtain the lenses from Bausch & Lomb Optical Co., Rochester, N. Y. (*e*) Part IV of Dischaull's "Natural Philosophy," price $1.50.

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(273) (*a*) I have found the table given in "Home Study for Machinists, Steam Engineers, Etc.," March, 1898, Answers to Inquiries, No. 141, useful in a variety of ways. One of its uses is to space off a certain number of degrees on a circle of given diameter. For instance, to space off 9°, turn to the table, take the multiplier opposite 40 holes and multiply by the diameter of the circle. The result will be the length of the chord. Please give the multipliers for all numbers from 271 to 360, or, better, from 3 to 360. (*b*) Give another method by which degrees may be determined over rough and uneven surfaces where a bevel protractor cannot be used, but where a circle may be drawn. J. A. S., Providence, R. I.

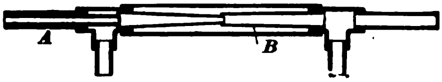
ANS.—(*a*) The chord of any angle can readily be found from a table of natural sines. Thus, to find the chord of 9°, find the sine of one-half of 9°, or $4\frac{1}{2}$°, which is .078459. Multiply this by 2 and by the radius of the circle, or what is the same thing, by the diameter, and the result will be the chord. You will see that the number .078459 is the one given in the table referred to, opposite 40 holes. If you prefer such a table to the table of sines, you can readily construct it as follows: Divide 180° by the number of holes, and from a table of natural sines find the sine

of the number of degrees in the quotient. This sine will be the multiplier for that number of holes. (*b*) In such a case, the angle can best be determined by laying off its chord.

***

(274) I have a tubular boiler 16 in. × 22 in., and want to make a simple injector for same. Will you tell me the best way it can be done? The steam pipe is ½ inch and the pressure 25 pounds gauge.
H. A. M., Franklin, La.

ANS.—Get a couple of tees, and make a steam nozzle, as shown in the figure at *A*; then make a



middle piece, as shown at *B*, and connect up as in the figure. The portion *B* will probably be more cheaply made in two parts, by spinning it out of seamless brass tubing.

***

(275) The sum of two numbers multiplied by the greater is 414, and the difference of the two numbers multiplied by the less is 65; what are the numbers?
J. P. P., Rogers, Ark.

ANS.—Let x equal the greater number and y the less. Then,

$$(x + y)\,x = 414 = x^2 + x\,y; \qquad (1)$$
$$(x - y)\,y = 65 = x\,y - y^2. \qquad (2)$$

Subtracting (2) from (1),

$$x^2 + y^2 = 349, \text{ or } x = \sqrt{349 - y^2}.$$

Substituting in (2),

$$y\sqrt{349 - y^2} = 65 \times y^2.$$

Squaring and combining,

$$y^4 - \frac{210}{2y^2} = -\frac{4{,}225}{2}.$$

Completing the square and solving,

$$y^2 = \frac{219}{4} \pm \frac{119}{4} = 25,$$

using the negative sign; whence, $y = \pm 5$.

Using the plus sign and substituting in (2),

$$x = \frac{65 + 25}{5} = 18.$$

***

(276) The mechanical drawings published in "The Mechanic Arts Magazine" are among the best I have ever seen. Would you kindly inform a constant reader the names of the books on that subject that you take as standards for your drawings?
W. W., Washington, D. C.

ANS.—We use no book as a standard; our work is our standard; we are glad that you like it.

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(277) A and B each invest $640 in one section of land; A is to pay $2.25 per acre, and B is to pay $1.75 per acre. How much land will each receive?
G. D., Anaconda, Mont.

ANS.—This question, like the Wandering Jew, never dies; it is probably older than the pyramids, but still continues to puzzle the unwary. There is no solution, because the conditions given render it impossible.

***

(278) Kindly tell me how I can construct a Bunsen burner to use gasoline instead of illuminating gas.
F. D. H., Jersey City, N. J.

ANS.—Build a common Bunsen burner in the ordinary manner, and arrange a chamber or coil around it through which the gasoline must pass to the burner, in such a manner that the gasoline will become vaporized before reaching the burner. Run a small pipe from your Bunsen burner to a gasoline storage tank somewhere higher than the burner, and place a valve in the pipe near the burner. Construct a cup underneath the coil or chamber, to catch the liquid gasoline when the valve is first opened, for the purpose of heating the coil when this liquid is ignited. These are the principles of a gasoline burner. Incorporate the Bunsen principles with them and you will have a gasoline Bunsen burner. It is much cheaper for you to purchase one of these burners than to make one.

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(279) An electric battery is constructed as follows: The bottom of a shallow lead or carbon tray is covered with a layer of zinc scraps, over which is placed a layer of cotton cloth which is moistened with salt and water. Porous carbon rods are laid on top of the cloth, these rods forming one pole of the battery and the tray the other. Why is this not a good battery, and why has it not been a success?
S. T., Houston, Tex.

ANS.—None of the tray forms of primary battery appear to have proved successful in practice, although a number of them have been brought out. Such batteries may give quite as high an E. M. F. as the ordinary batteries, and may also have a very low internal resistance, but their shape renders them awkward for commercial applications. The evaporation from them is also great, so that they are apt to dry up quickly. We think that the cotton cloth in the battery you name would be a decided objection. This would become clogged up, and in time become rotten, and would have to be renewed.

***

(280) (*a*) Can I use a mixture of white and red lead as putty for bedding the glass into an aquarium? (*b*) Is there any danger that the fish will be poisoned by the use of this putty? (*c*) Is there anything else that could be used?
J. C. S., Chicago, Ill.

ANS.—(*a*) Yes. (*b*) No; the water of an aquarium is too frequently changed to contain sufficient lead at one time to be dangerous to the life of the fish. (*c*) The following cement, used at the Zoological Gardens of London, England, can be highly recommended; it is good for either salt or fresh water. Take of finely powdered litharge, fine dry sand, and plaster of Paris, each 3 parts, by measure; finely pulverized rosin, 1 part. Mix thoroughly, and make into a paste with boiled linseed oil to which some drier has been added. After it has stood for 15 hours, however, it loses its strength. When well made of good materials, this cement will unite glass and iron so firmly that the glass will often split rather than part with the cement.

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(281) (*a*) In "Home Study Magazine," July, 1897, article entitled "How to Lay Out Gear Teeth," you state that $r = a + c$, and in the proportions for the layout you have $r = .515''$. If $a = .239''$ and $c = .0375''$, should not $r = .2765''$? (*b*) Please give accurate method for finding the diameter of a worm-wheel, the pitch and number of teeth being given.
C. N., Torrington, Conn.

ANS.—(*a*) The value $.515''$ is the length of the tooth, not the root, as stated in the article. The root is $.239'' + .0375 = .2765''$, as you state; then the length is $a + r = .239 + .2765 = .5155''$, say $.515''$. (*b*) The circular pitch of the wheel is equal to the divided normal pitch (which we suppose to be the pitch you mean) divided by the cosine of the angle of the worm-thread.

Let a = angle of worm;
p = circular pitch of wheel;
p' = normal pitch of wheel;
d = diameter of wheel;
n = number of teeth in wheel.

Then, $$d = \frac{n\,p}{\pi} = \frac{n\,p'}{\pi \cos a}.$$

This formula applies only to a single-thread worm

(282) (*a*) If a weight of 200 pounds falls 15 feet, what would be the force of the blow in pounds when it struck? (*b*) What is the best way to replace a cracked water pipe, whose dimensions are 36 inches by 12 feet? (*c*) Is there any other pipe-cutting machine besides the D. W. French pattern for large pipes?
C. P., Waterbury, Conn.

ANS.—(*a*) The striking force of a falling weight depends on its own material as well as on that of the body struck, for the energy accumulated in the falling weight is expended in doing the work of compressing both the striking body and the body struck. This work is equal to the pressure between the bodies multiplied by the linear amount of compression. The energy of the falling body being equal to $W h$, the weight multiplied by the height of the fall, we have

$$P c = W h, \text{ and } P = \frac{W h}{c},$$

where P = pressure between the bodies, and c = linear amount of compression. Thus, if we supposed the weight to be of comparatively hard material, and that it sank into the ground $\frac{1}{2}$ inch when it struck, then the pressure between it and the ground would be

$$P = \frac{200 \times 15}{\frac{1}{2 \times 12}} = 72{,}000 \text{ pounds.}$$

(*b*) Split off the cup of the cracked section, and melt out the lead at the other end; enough must be split off to permit the pipe to be raised out. The new pipe must be put on in two sections, connected by a collar. (*c*) The following firms make pipe-cutting machines: Armstrong Mfg. Co., Bridgeport, Conn.; Bignall & Keeler Mfg. Co., Edwardsville, Ill.; Curtis & Curtis, Bridgeport, Conn.; Merrell Mfg. Co., Toledo, Ohio; Oster Mfg. Co., Cleveland, Ohio.

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(283) Where and at what price can I get a book that will teach me how to lay out boiler work?
J. R., Philadelphia, Pa.

ANS.—"The Boiler Maker," by Samuel Nicholls, price \$2.50, can be obtained of The Technical Supply Company, Scranton, Pa.

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(284) (*a*) In making a wet battery where copper and zinc form the elements, which plate should be the larger, or does it make any difference? Does it make any difference as to what size of wire is used to connect the plates? (*b*) Give a rule for finding the displacement of ships. (*c*) Give a rule for finding the safe speed of flywheels.
S. S., Ballard, Wash.

ANS.—(*a*) It makes no difference, as far as the voltage obtained from the battery is concerned, whether the zinc is as large as the copper or not. The zinc, being the element that wastes away, will last longer if it is made heavy, and the internal resistance of the battery will be lowered if it is made so as to present a large surface. If too fine wire is used in connecting up the battery, a good part of the energy delivered by the battery will be lost in heating the wire. About No. 16 or 18 B. & S. wire is generally used for this work. (*b*) The displacement (in tons of 2,240 pounds) is given approximately by the following formula:

$$T = \frac{L \times B \times D \times K}{35},$$

where T = displacement in tons;
L = length of boat in feet;
B = extreme breadth in feet;
D = mean draft in feet.

K is a constant that depends on the style of boat under consideration. For racing yachts, with deep keels, it varies from .22 to .33; for modern merchantmen, from .55 to .75; for ordinary small boats, about .50 is a fair estimate. For fresh water the divisor in the above formula is 35.93. (*c*) The maximum allowable rim velocity of ordinary flywheels is 6,000 feet per minute, but 5,000 feet per minute is safer. If D is the diameter of the wheel in feet, then the maximum safe value of the revolutions per minute will be

$$\text{R. P. M.} = \frac{6{,}000}{3.1416 \times D}.$$

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(285) In testing a boiler, what are the relative strains to the boiler in testing by hydraulic and steam pressure?
H. W., Selma, Ala.

ANS.—A boiler is not *tested* by steam pressure at all, but by water pressure about $1\frac{1}{2}$ times as great as the steam pressure it is to carry in regular service. There are two ways of performing the test. In both, the boiler is completely filled with water. In one method, a pump is used to produce the pressure; in the other a gentle fire is made under the boiler, and the pressure thus obtained by the expansion of the water. The latter method is preferred by many as being less severe on the boiler.

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(286) I wish to know if there are any records put up in the way of rapid railway construction. If so, I would like to have an idea of the nature and extent of the work undertaken.
W. A. J., Hunterville, New Zealand.

ANS.—We have not at hand the statistics you want. We are of the opinion, however, that some of the most expeditious work of this kind has been done in Egypt in connection with the British advance into the Soudan. The railway in question was for military purposes and was pushed with the utmost vigor. It was for this railway that the Pencoyd Company lately made the Atbara bridge, the speedy supplying of which attracted so much attention.

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(287) I have been reading, in the Report of the United States Coast and Geodetic Survey for 1897, a paper on "Magnetic Dip and Intensity," in which I find several expressions and symbols which I do not understand, and several quantities mentioned that I do not know how to determine. Will you kindly enlighten me on the following points: (*a*) What is meant by "C. G. S. units," and "F. G. S. units"? (*b*) What is the meaning of "dip θ," "horizontal force H," "vertical force V," "total force F," and the indexed letters θ_{1900}, H_{1900}, V_{1900}, F_{1900}, and how are these quantities obtained? (*c*) Can the declination at any time be computed from the data given in the paper referred to above, and if so, how?
H. E. B., North Windham, Conn.

ANS.—(*a*) The abbreviations "C. G. S." and "F. G. S." stand, respectively, for *centimeter-gram-second* and *foot-grain-second*. In the C. G. S. system of units, the units of length, mass, and time are, respectively, the centimeter, the gram, and the second; in the F. G. S. system, the units are the foot, the grain, and the second; hence the names. When we say, for instance, that the velocity of a body, expressed in C. G. S. units, is 50, we mean that the body has a velocity of 50 centimeters per second. In either system, the unit of force is that force which, when acting during one second on a unit of mass, imparts to it a velocity of a unit of length per second. (*b*) The *dip* of the magnetic needle is the angle made by the direction of the needle with a horizontal plane. In the paper you refer to, the dip in general is denoted by the letter θ, and is expressed in degrees, minutes, and tenths of a minute. From the observed values of θ in different years, the approximate dip in the year 1900 has been calculated. This calculated value is denoted by θ_{1900}. By the "total force F" is meant the intensity of the earth's magnetic attraction at any particular point. The "horizontal force H"

and the "vertical force V" are the horizontal and the vertical component, respectively, of the "total force F." It is to be carefully borne in mind that F, H, and V are expressed in units of magnetic intensity, not in ordinary units of force. These quantities are calculated by formulas of mechanics, the numerical data for which are determined by very delicate and careful observations and measurements. We have no space to go into details on this subject, but would refer you to almost any good work on physics or electricity, such as Ganot's "Physics," S. P. Thompson's "Elementary Lessons in Electricity and Magnetism" (with Murdock's Notes), C. Maxwell's "Electricity and Magnetism," or A. Gray's "Absolute Measurements in Electricity and Magnetism." The indexed letters F_{1900}, H_{1900}, etc. denote the calculated values of F, H, etc. for the year 1900. (*c*) The formulas for computing the declination at any given time from observed declinations are somewhat complicated and uncertain. There is no general formula; especial formulas have been constructed for several localities of this country. You may find them in the Report of the United States Coast and Geodetic Survey for 1886; also, in Johnson's "Theory and Practice of Surveying," and in Raymond's "Plane Surveying."

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(288) (*a*) In "Home Study Magazine," April, 1898, Answers to Inquiries, No. 117, it is not stated at what speed the 2½ horsepower is obtained; please give speed. (*b*) Given in a gas engine: piston, 2½ inches in diameter; stroke, 3 inches; compression, 60 pounds per square inch; revolutions per minute, 600; fitted with two flywheels, each 9 inches in diameter, and rim 1 inch thick; what breadth of wheel face is required? (*c*) If the diameter of a flywheel is increased, what effect has it upon its working properties, the number of revolutions per minute remaining the same? A. C. G., New York, N. Y.

ANS.—(*a*) The speed at which the power given was based was about 400 revolutions per minute. The power given in the answer was the nominal horsepower. Under the best of conditions, the actual horsepower would probably be somewhat greater. (*b*) Under the given conditions, the face of the wheel should be not less than 6 inches. The weight required, however, depends considerably on the class of work which the engine is doing. For very close regulation, such a weight would probably be too small to give good results. (*c*) The working properties of a flywheel, regarded as an agent in controlling the regulation of the speed of an engine, vary as the square of the diameter, the number of revolutions, and the weight remaining the same.

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(289) (*a*) Why are locomotives built with small driving wheels when great tractive power is desired? (*b*) Of two traction engines, one with 6-foot and the other with 4-foot traction wheels, which is the more powerful, both engines to make the same number of revolutions per minute at the crank, to travel at the same speed, and the sprocket wheel of each to be 1 foot less in diameter than the traction wheel? H. R., Newdale, Manitoba.

ANS.—(*a*) When a locomotive moves a train it performs work. Work comprises two factors—resistance overcome and distance through which it is overcome. When steam forces a piston along, against a resistance, it performs a certain amount of work—say 50,000 foot-pounds in a complete stroke. Now, by means of rods, crank, and wheels, we make this work take the form of transporting a vehicle in a linear direction. The work at our disposal in the present case is, we will suppose, 50,000 foot-pounds, and we can vary the size of the factors, feet and pounds, to suit conditions. In an express engine we want speed—to move a light weight rapidly. In heavy freight work we want to move heavier weights more slowly. Thus, we can, in the first case, move 2,500 pounds through 20 feet; 5,000 pounds through 10 feet in the second; the time, the duration of one complete or double stroke being the same in both cases. Thus, if the engine is for hauling heavy loads up steep grades, we should use a wheel half the circumference (i. e., half the diameter) of the wheel on the express engine, and so be able to handle double the load. The principle is simply this: We can exert a certain amount of power in the cylinder, and we can either expend this in moving a great weight a short distance, or a light weight a longer distance—in the same time, of course. If, then, in each case our stroke is 2 feet, and the piston areas and steam pressures the same, we shall have the same power exerted during one stroke. In the express engine we move, say, W pounds through x feet; in the freight, 2 W pounds through ½ x feet; the work done is Wx foot-pounds in each case. We may add that the figures representing the loads are the drawbar pulls; there are also two cylinders to deal with. (*b*) The engines will be equally powerful, since the gearing, in each case, is so arranged that, for a given travel of the engine, the piston displacement is the same. In one minute each engine makes, say, 200 revolutions; conditions being equal (you say nothing to the contrary), the power exerted in the respective cylinders is the same. If, then, in one minute each engine travels over the same distance, the loads moved will be the same, according to the reply to (*a*).

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(290) I am building a gasoline engine of the two-cycle type, the diameter of cylinder being 4½ inches and the stroke 5 inches. (*a*) What should be the distance from the cylinder head to the piston when the charge is compressed, and what would be the pressure per square inch? (*b*) Assuming the exhaust port to have a width of ½ inch, what should its length be? (*c*) Assuming the intake to be ⅜ inch wide, and the pressure of the charge as taken from the crank-chamber to be 11 pounds per square inch, what should be the length of the intake? (*d*) How far open should the exhaust be at the moment the intake begins to open? The ports are to be opened and closed by the piston. (*e*) What will be the power of the engine under the best conditions, when making 250 revolutions per minute? (*f*) If in your judgment my chosen port widths are not right, give the correct figures. (*g*) Which is the best, to spray the gasoline into the cylinder or to take it through a carbureter? H. W. C., Chicopee Falls, Mass.

ANS.—(*a*) The distance from the cylinder to the piston when the piston is at the end of its stroke should be about 2½ inches. The charge will then be compressed to about 55 pounds per square inch. (*b*) The length of the exhaust port, measured around the inside circumference of the cylinder, should be about 4 inches for a width of ½ inch. (*c*) The length of the intake port should be about the same as that of the exhaust port. (*d*) We would place the ports in such a manner that the exhaust port would be open its full width at the instant the intake port begins to open. (*e*) Under the best working conditions, the power of the engine when making 250 revolutions per minute would probably be about 2½ horsepower. (*f*) We think the port widths you have chosen will give satisfactory results. (*g*) To give the best results, the gasoline should be taken into the cylinder through a carbureter.

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(291) I am about to make a hob tap for a 1-inch gas-pipe die. Shall I set my tool with the taper of the tap, or in line with the center of the lathe? A. O. L., Erie, Pa.

ANS.—Set your tool so that it will make a right angle with the line joining the centers, i. e., with the center line of the tap.

(292) (*a*) What is the cause of the noises in a boiler connected to a cook stove? (*b*) Would a boiler make this noise if properly connected? (*c*) Where can I get a slide rule with which calculations are made by means of logarithms? (*d*) Will cylinder oil in a boiler cause it to prime? X.

ANS.—(*a*) They are caused by the generation of steam in the waterback and the rapid condensation of the steam when it encounters the colder water in the boiler. Choked circulation pipes between range and boiler will cause this; or a waterback too large, or boiler too small, for the requirements of the building. (*b*) Not if the waterback and boiler are properly proportioned. (*c*) From The Technical Supply Co., Scranton, Pa. (*d*) If it is a pure mineral oil it is not likely to produce priming unless the water is particularly bad. Much depends on the character of the oil and the impurities in the water. It is, however, always best to keep cylinder oil out of the boiler as completely as possible.

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(293) (*a*) I have a telephone on a line 15 miles long. The transmitter refuses to talk, while the receiver serves the purpose of both transmitter and receiver. I have been unable to find any loose connections in the circuits. What is the cause, and remedy? (*b*) Will a telephone line receive enough induction from a 5,000-volt alternating system to seriously damage its talking service? The telephone line is grounded, but is on separate poles from the electric line. It passes under the electric line several times, but is on the opposite side of the road the greater part of the distance. E. H. S., Treka, Cal.

ANS.—(*a*) It is impossible to state definitely from the meager description you have given. If the transmitter is of the granular type, it may be packed, or the batteries may be run down. The remedy, in one case, is to refill the transmitter, and in the other, to renew the batteries. It may be that the switch hook does not complete the local circuit when raised, in which case the contacts should be carefully overhauled. Perhaps the primary of the induction coil is open, or the secondary is short-circuited. (*b*) Yes; and there is no known remedy except to make the telephone line a complete metallic circuit, with its sides transposed at frequent intervals. You would probably obtain induction on lines a mile apart if they ran parallel for a distance of 15 miles.

***

(294) (*a*) Can aluminum be soldered? (*b*) What flux is the proper one to use? I tried to solder aluminum to cast iron, but did not meet with success in using common soldering acid. H. A., Jersey City, N. J.

ANS.—(*a* and *b*) Take of aluminum and zinc in any of the following proportions: 8 parts aluminum to 92 parts zinc; 12 aluminum to 88 zinc; 15 aluminum to 85 zinc; 20 aluminum to 80 zinc. Melt the aluminum; add the zinc slowly; finally, add some fat and stir with an iron rod, and cast. For a flux, use 3 pints of copaiba balsam, and 1 pint of Venice turpentine to which a few drops of lemon juice have been added. Dip the point of the soldering iron into the flux.

***

(295) I have a Wimshurst influence machine that sparks at the brushes and combs, but the electricity does not pass between the balls on the conducting rods. (*a*) What is the cause and remedy for this? (*b*) How can the machine be reversed? C. C. S., Kansas City, Kan.

ANS.—(*a*) The usual cause of these machines not starting up is poor contact between the brushes on the neutralizing arms and the revolving sectors. See that these make good contact, and also see that the machine is perfectly dry and free from dust. The terminal rods should be kept apart when starting until the sectors have become fully charged. Perhaps the neutralizing rods have become shifted from their proper positions. It might be well to try shifting these backward and forward slightly. There is a possibility that the plates are being rotated in the wrong directions. (*b*) By giving one set of sectors an initial charge opposite to that which they previously had.

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(296) Please explain the statement regarding single-acting pumps, on page 240 of "Mechanics' Pocket Memorandum," as to water flowing into the barrel of the pump when the piston is descending. G. Q., Paris, Can.

ANS.—The action referred to will occur when the column of water is moderately long, the stroke short, and the pump worked at high speed. A column of water once started in motion tends to keep in motion by virtue of its inertia, and will continue to ascend after the impulse given it by the piston has ceased. If the piston makes the stroke quickly, it gives the column a new impulse before it has come to rest. Hence, the foot-valve will remain continually open, and, as stated, more water will flow than theory indicates. This phenomenon is usually termed *negative slip*.

***

(297) Please inform me which of these two calculations, in finding the effective moment, is correct: Length of lever equals 36 inches; weight of lever, 22 pounds; weight of valve and stem, 8 pounds; distance from fulcrum to valve, 4 inches. It is assumed that the center of gravity of the lever is at its middle point.

$$\frac{18 \times 22}{4} + 8 = 107; \text{ or, } \frac{18 \times (22 + 30)}{4} = 135.$$

M. J. B., New York, N. Y.

ANS.—The first calculation is correct; it gives the downward pressure at the valve, due to the weight of the lever, valve, and stem.

***

(298) Please inform me where I can get some information regarding liquefied air. D. S., Winnipeg, Can.

ANS.—Almost anywhere. The current numbers of the journal "Ice and Refrigeration," published at Chicago, Ill., contain many good articles on this subject. You can procure a book on liquid air and the liquefaction of gases, by Dr. T. O'Connor Sloane, from The Technical Supply Company, Scranton, Pa., price $2.50.

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(299) (*a*) In running feeders 10 miles for an alternating-current circuit, would the line loss be affected by changing the spacing of the wires from 18 inches to 48 inches? (*b*) Would the drop be less at 48 inches than at 18 inches? (*c*) I have trouble with the salts creeping on the cells in my telephone; please tell me the cause and remedy. (*d*) Please describe and illustrate the Hancock inspirator. (*e*) How much current would each lamp get if three, in parallel, were connected in series with one lamp? The lamps are 16-candlepower, 110 volts. L. C. H., Bradford, Vt.

ANS.—(*a*) The greater the distance between a given pair of wires carrying an alternating current, the greater will be the line loss. The amount would depend on the size of your feeder and the frequency. (*b*) No; it would be greater at 48 inches. (*c*) Caused by evaporation at the contact surface between the liquid and the glass, causing the salt to be deposited on the glass. Then, by capillary attraction and evaporation, more and more salt is deposited on the glass, gradually covering the entire exposed surface. It can be prevented by coating the entire upper surface of the glass jar, an inch or so down, with wax or paraffin. To do this, melt the wax or paraffin in a

dish, and dip the top of the glass jar into the melted wax. (*d*) See "Home Study Magazine," September, 1896, article entitled "The Injector." (*e*) Assuming a 16-candlepower 110-volt lamp to have a resistance, when hot, of 220 ohms, the current in one would be .375+ ampere, and in each of the three in parallel, .125+ ampere.

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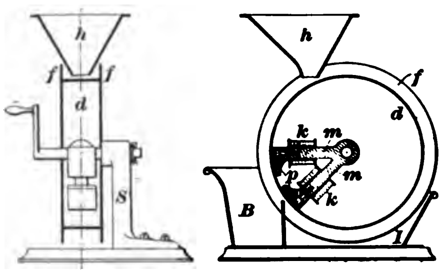
(300) I desire to make a magnetized drum 10 inches in diameter and 12 inches long, for separating iron from copper filings. I have been informed that it requires 30 pounds of No. 20 double cotton-covered magnet wire. How shall I proceed to successfully wind the magnet core for the same?

H. D., Gilta, Cal.

ANS.—The best form of magnetic separator that we know of that employs a rotating drum is the one illustrated in the accompanying figure. The magnet cores *m*, *m* are cast in one piece and fastened to the pedestal *S*. After the coils *k*, *k* are put on, the pole pieces *p* are fastened in place by means of machine screws, as shown. The drum *d* is made of copper or



brass, and has a flange *f* on each side. The filings are fed to the revolving drum by the hopper *h*. The copper filings, not being attracted by the magnets, fall into the box *B*, while the iron filings are carried past the partition and fall into *I*. The magnets and partition should be adjustable, so that the best position for working can be found.

***

(301) (*a*) I am running a 10″ × 31″ Allis Corliss engine making 93 revolutions per minute. Sometimes the engine runs nice and smooth, and then again unsteady. For about five revolutions it will gradually slow down; then, for the next eight revolutions it will increase in speed until above the normal, when it will slow down again. While the difference in speed is not very much, it is enough to be annoying. With 80 pounds pressure the engine runs steadier than with 90 or 100 pounds. The governor belt does not slip, and the governor runs perfectly free. What is the trouble? (*b*) Next winter we intend to run our exhaust pipe, after it leaves the closed exhaust heater, through the mill and down into a cistern. The distance will be about 180 feet; there will be seven elbows in the exhaust pipe. Will this increase the back pressure? (*c*) Our boiler, which is of the horizontal return-tube type, is 16 feet long, has 54 flues, and 16 square feet of grate surface. In a run of eleven hours I burn about 3,000 pounds of North Dakota lignite, and use about 1,400 gallons of water. Is this a good boiler efficiency? The bridge wall comes within 8 inches of the boiler.

F. J. V. K., Glen Ullin, N. Dak.

ANS.—(*a*) It is possible that your governor is too sensitive, and we would advise you to regulate the dashpot. We are inclined to doubt your statement about the governor being perfectly free, and would recommend a careful overhauling. However, without a personal examination we can only offer suggestions. (*b*) Yes. (*c*) As you are evaporating only about 4 pounds of water per pound of coal, the efficiency is not very great. The heating value of lignite averages about 10,000 British thermal units; hence a pound of it can evaporate 10,000 ÷ 966 = 10.36 pounds of water from and at 212° Fahrenheit. Assuming a feedwater temperature of 60° and a steam pressure of 100 pounds gauge, 1,167 British thermal units will be required to evaporate 1 pound of water. Hence, under these conditions, a pound of lignite will evaporate 10,000 ÷ 1,167 = 8.57 pounds of water. As you evaporate only about 4 pounds, your efficiency is less than 50 per cent., which is rather low. It may be the case, however, that the particular run of lignite you are using has a very low heating value, in which case your efficiency would be much higher than here calculated. The efficiency may then be all that could be expected.

***

(302) Please give a formula for coating a paper that will print black lines on a white ground under an ordinary tracing. W. H., Poughkeepsie, N. Y.

ANS.—A paper for direct printing of black lines on a white ground may be prepared as follows: In 9 ounces of water dissolve

Gelatine	3 drams.
Perchloride-of-iron solution	6 drams.
Tartaric acid	3 drams.
Ferric sulphate of iron	3 drams.

Apply two coats of this solution to the surface of a heavily sized paper, allowing each coat to dry thoroughly. Print, as with blue-process paper, under a tracing having somewhat heavy and well-defined lines, and develop the print in a solution consisting of 6 drams of gallic acid dissolved in 32 ounces of water and 6¼ ounces of alcohol. The lines will appear strong and of a deep purple-black color, and the ground will assume a cream tint, afterwards changing to a pale gray. The print should then be washed in several changes of water and hung up to dry. Additional lines, on this form of print, can be made with ordinary drawing ink; existing lines can be removed only by careful rubbing with an ink eraser.

***

(303) Will you please tell me what method is generally used by designers in determining the stresses in bridge girders and roof trusses? Also, would you please inform me of some book that treats thoroughly on this subject? As it will be used by one familiar with higher mathematics, the use of such will not be an objection. C. S. G., Erie, Pa.

ANS.—There are two: namely, the method of moments, which is purely analytical, and the graphical, which consists in the determination of the stresses by means of geometrical diagrams drawn to scale. They are both used extensively, though the graphical is more in favor with bridge and structural-steel shops, as the liability of error in using this method is reduced to a minimum. A good book on the subject, treating on the practical designing of framed structures, and giving both the analytical and graphical methods, is Johnson's "Theory and Practice of Modern Framed Structures." It can be had for its price ($10.00) from The Technical Supply Company, Scranton, Pa.

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(304) (*a*) Referring to "The Steam-Electric Magazine," July, 1899, Answers to Inquiries No. 139, will the coil described be suitable for X-ray work, and for exciting Geissler tubes? (*b*) Is a vibrator required in connection with this coil? (*c*) Please recommend a book giving drawings and directions for constructing a 1-kilowatt dynamo, preferably 4-pole.

H. A. S., Chicago, Ill.

ANS.—(*a* and *b*) Yes; reference is made to the vibrator in the answer you refer to. (*c*) "How to Make a One-Horsepower Motor or Dynamo," by A. E. Watson, price 50 cents, may be obtained from The Technical Supply Company, Scranton, Pa.

(305) (*a*) I would like information as to the best way in which to construct a bar and transom at *a* in the accompanying sketch, Fig. 1. I want the same so constructed that it will be wind- and weather-tight. The upper sash or transom is stationary, and the lower sash is hung with weights. (*b*) What would be the best way to screw the sash locks to the lower sash?

F. J. C., Allentown, Pa.

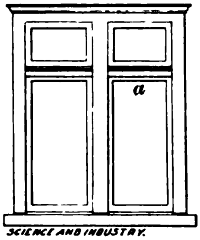

Fig. 1.

Ans.—(*a*) We would suggest that you construct the transom bar shown at *a*, Fig. 1, as shown in the section, Fig. 2. In order that the upper transom sash will be wind- and weather-tight, the sill *f* must be rabbeted into it, and as a neat external appearance is evidently required, the transom bar may be constructed with a facia *g* and mold *h*, as shown. Since this construction increases the width of the lower transom bar beyond that usually employed, it might be well, for the sake of appearance, to introduce the scratch bead *e*. The upper rail of the hung sash can be constructed with a stop *j*, which should preferably

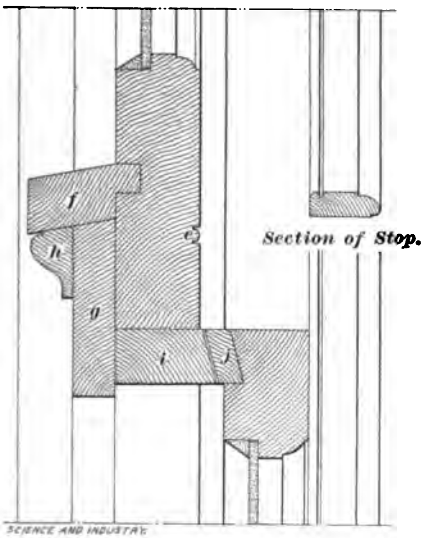

Fig. 2.

be made of close-grained hard wood, such as birch or cherry, and fastened to the upper rail by gluing and countersunk brass screws. A weather joint will thus be obtained for the hung sash. (*b*) Possibly the best manner in which to lock the movable sash is to insert in the stile a mortise sash lock. These are well adapted for sashes where it is undesirable to place the lock upon the upper surface of the top rail. They can usually be obtained from any first-class hardware store.

***

(306) Will you refer me to some book that gives a full and accurate description of plastering and the various ways of laying out groined ceilings, elliptical work, cornices, and other information pertaining to the trade? R. G. MacI., Germantown, Pa.

Ans.—A book called "Plaster and Plastering, Mortars and Cements" is a complete guide to the plasterer in the preparation and application of all kinds of plaster, stucco, Portland cement, hydraulic cements, Rosendale and other cements. The price of this book is $1.00. There are several other books that treat more or less on the subject; for instance, "Notes on Building Construction," Volume 2, and "Building Construction and Superintendence," Part I. The former is an English book and can be obtained for about $2.50, while the latter, written by F. E. Kidder, deals with American practice, and can be purchased for $4.00. Any of the books mentioned may be obtained from The Technical Supply Company, Scranton, Pa.

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(307) Can you give me a receipt for mahogany stain in distemper; also, one in oil?

J. S., San Francisco, Cal.

Ans.—Mahogany stain may be obtained from a thin mixture of burnt sienna, ground in vinegar. The graining and staining is done while wet, with the same stain thickened with more sienna. In the case of hard woods the filler should be stained also before being used. We do not know of any receipt for mahogany oil stain.

***

(308) Much of the iron hardware and house fittings have a dull black finish that the trade calls Bower-Barff. Can you give me some idea of the process by which this finish is produced?

J. C. M., Boston, Mass.

Ans.—The process for preserving iron known as Bower-Barff consists in raising the temperature of the iron in a closed vessel, and subjecting it for a period of 12 hours to the action of superheated steam at the same temperature. Black oxide of iron is thus formed on the surface, and there results a dull black finish or skin. When used for interior work, it will retain its color for a considerable time, but when used for exterior work, it loses its color ere long by reason of corrosion.

***

(309) I have a derrick that is located on a wharf and is used for loading stone. The braces are 10″ × 10″ hard pine. The man that built it said the braces would last longer if they were left unpainted. Lately I have noticed that the braces are turning black in places, and would like to know if there is anything I can do that will preserve them.

W. A. A., Spruce Head, Me.

Ans.—Under some conditions the derrick builder would be right in recommending that the braces be left unpainted; for instance, if the wood were not thoroughly seasoned, or if it contained considerable moisture, to paint or apply any preservative coating to the outside would be like leaving vermin inside a corn chest and locking them in. The moisture and fermenting constituents in the sap are unable to get out, owing to the pores being filled, and, by remaining, cause rot and decay. If the discoloration on the braces is incipient decay, it will be somewhat difficult to remedy. The only way to prevent the destruction, that we can suggest, is to ascertain whether it is on the surface, and if so, the discoloration or appearance of decay should be planed off until the sound timber is reached. The braces may then be painted with any good preservative, such as linseed oil, coal tar, or any good paint. It has been found that coal tar, mixed with dry sharp sand, makes an excellent preservative where the timber is subjected to heavy stresses of wind and weather, as we suppose is the case with the derrick you mention. In Holland, to preserve the gates, drawbridges, sluices, etc., they are coated with a mixture of pitch and tar, in which is strewn small pieces of cockle and other shells, beaten almost to a powder, and mixed with sea sand.

(310) What do you consider to be the best method of fixing large lights in swinging doors? Where the glass is fixed in the ordinary way, I find that the violent slamming of the door will frequently break or crack the glass. Can you offer any suggestion that might be likely to prevent such a contingency?
C. B. C., Cleveland, Ohio.

ANS.—It is best in such doors to have a solid rebate, and to provide a loose bead instead of putty. The bead should preferably be secured with screws. Where the light is large and the door is subjected to shocks or vibrations, a strip of felt, rubber, or even double thickness of blotting paper, stained to suit, or painted black, should be placed between the wood and the glass; a cushion is thus formed for the glass, and the danger of breaking or chattering will be eliminated. For outside doors, or others liable to slam with the wind, it is well to attach a door check, such as the "Blount" or "Bardsley," when there will be no liability of the glass being broken.

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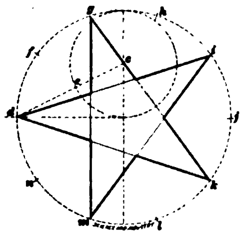
(311) Will you please inform me how to draw a five-pointed star, inscribed in a circle?
F. M. B., Calumet, Mich.

ANS.—Draw a circle of the same diameter as the star that you wish to inscribe, as shown in the accompanying figure. Within the circle, draw a small circle equal in diameter to half that of the larger. Connect the center *c* of the small circle with the point *d* at which the horizontal diameter intersects the large circle. Then, with a pair of dividers, step off the distance *d c*, as a chord around the circumference of the large circle. In this manner the points *e*, *g*, *h*, *i*, etc. will be obtained. Connect alternate points, as shown, and the outline of the star will be defined.



***

(312) How can I thaw a frozen water pipe with current from a 110-volt direct-current machine?
G. W. T., Crested Butte, Colo.

ANS.—Run heavy conductors to the ends of the pipe to be thawed out; if the latter cannot be reached, make the connections as near as possible to the portion containing the ice. Make your connections with heavy copper clamps. To determine the amount of current to supply, calculate the cross-section of the pipe and allow 1,000 amperes per square inch. If the current is not sufficient to thaw the pipe, increase it. Forty minutes at the utmost should suffice. Control the current by means of a water rheostat.

***

(313) (*a*) What is the best way of applying asbestos in flour form to a hot-water heater? My idea is to mix it with some liquid, and so make a mortar that when laid on the smooth surface of the heater will adhere securely. (*b*) I am thinking of putting a water-heating apparatus in a greenhouse whose dimensions are 100 feet long, 20 feet wide, and 9 feet high, and exposed on two sides, having a $\frac{1}{3}$-pitch roof. How must I arrange the pipes so as to get the most satisfactory results, and what size pipes should be used? I wish to employ a low-pressure system of heating, and to place the heater at one end, above the ground.
F. W. R., New London, Ohio.

ANS.—(*a*) It is customary among steam fitters to mix asbestos into the cement or mortar by the introduction of water and plenty of "elbow grease." The cement must be thoroughly mixed and made very plastic, when it is applied with a trowel in the ordinary manner. To keep it from cracking and falling off a smooth surface, such as the outside of a hot-water heater, we would advise you to encircle the heater with wires, or a screen, or something to which the mortar can readily adhere. (*b*) The proper way to arrange pipes so as to get the most satisfactory results, is to place them under the benches and around the exposed walls as much as possible, but if you set the heater above the ground, that is, above the level of your coils, the circulation will be too sluggish for good results; we therefore advise you to dig a pit and set the heater at least 3 feet below the coils, in the ordinary manner. It is foolish to court trouble by setting the heater higher than the heating coils.

***

(314) I have a job on hand where it will be necessary to fasten some sheet copper to a stone surface. What simple method can I use to make a good job and leave no nail or screw heads open to the weather?
R. A. M., New Haven, Conn.

ANS.—A common method is to cut holes from $\frac{1}{4}$ to [illegible] inch in diameter at intervals all over the surface of the stone. The holes are cut wider at the bottom than at the top, so that the lead plugs cannot be pulled out. A rod, whose diameter is a little less than that of the screws to be used, is greased and placed upright in the hole, and lead is poured around the rod until the hole is filled. The rod is then pulled out and the sheet copper is screwed down to the lead plugs with brass screws. Expansion bolts are also much used. After the stone is covered the holes are located by tapping the copper sheet with a hammer. A washer is placed between the bolt head and the copper. When the bolt is screwed down, a tapered nut is drawn up and presses the sides against the edge of the hole. A cone is soldered over the fastener, whether made with a lead plug or with an expansion bolt, and makes it water-tight.

***

(315) Does the strength of a piece of timber depend on its weight? T. A. N., Ann Arbor, Mich.

ANS.—It is a well-established fact that with the same species the strength of wood varies with the dry weight (specific gravity), the heavier wood being the stronger. This law holds good not only for a given species, but, irrespective of species, for the four principal pines of our Southern states. This truth is of importance owing to the fact that the wood of these species of pines, so far, cannot be distinguished by its anatomical structure, and only with difficulty and uncertainty by other appearances, while in the lumber market substitution is not infrequent. With these pines, therefore, where strength alone is desired, it would be well to inspect the material by specific weight. The United States Department of Agriculture, Division of Forestry, state that their recent tests indicate "that probably in woods of uniform structure, strength increases with specific weight, independently of species and genus distinctions; i. e., other things being equal, the heavier wood is the stronger." The complex structure of oak, however, causes this wood to divaricate somewhat from the above rule.

***

(316) Please give the address of some firms that build small spring motors for running phonographs, etc.
I. N., Seneca Falls, N. Y.

ANS.—Regina Music Box Company, Rahway, N. J.; Otto & Sons, Jersey City, N. J.

***

CORRECTION.—In answer to question 239, printed in the October number of "The Mechanic Arts Magazine," there is an error in Fig. 4, where the parallels of latitude were inadvertently numbered in the reverse order of what they should have been. The numbers 60°, 45°, 30° in the parallels should be reversed; they should increase from the equator towards the pole.

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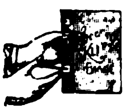

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Pages XXII and 436.

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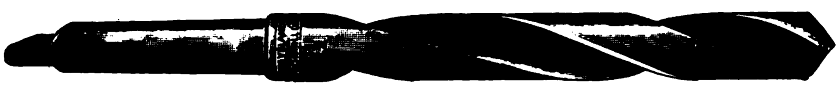

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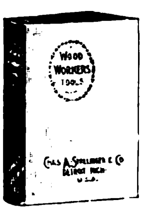

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Vol. IV. DECEMBER, 1899. No. 11.

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SCIENCE AND INDUSTRY

Vol. IV. DECEMBER, 1899. No. 11.

PECULIAR AIR-CURRENTS OF THE WORLD.

Ernest K. Roden.

HOW WIND IS CAUSED—THE TRADE WINDS AND THE MONSOON—PECULIARITIES OF TROPICAL STORMS—THE LAST WEST INDIAN CYCLONE.

OUR globe, in its endless travel through space, carries with it, as every one knows, an enormous quantity of air. When some portion of this air is put in motion, we say that "a wind is blowing." Wind, therefore, may be defined as air in motion.

Then comes the question: How is wind caused? what powerful fan puts the air in motion, and pushes it along at so great a velocity that it sometimes is able to carry with it stones, trees, and houses, the weight of which would tip the scale at several tens of tons? The majority of our readers are probably familiar with this cause, but many, for reasons of their own, are not, and to them the following may prove interesting.

All winds—the raging tempests as well as the gentle evening breezes—are caused, directly or indirectly, by changes of temperature. If, from any cause, two neighboring regions become very unequal in temperature, the air of the warmer region, being lighter than the other, will ascend and spread out over the top of the colder, while the heavier air of the colder region will flow in below to supply its place. Thus a motion is produced, the swiftness of which will depend on the difference in temperature between the two regions. The greater the difference, the greater the velocity of the wind; and this wind, or rather these winds—one blowing from the colder region to the warmer, along the surface of the earth; the other

FIG. 1.—THE CALM BEFORE THE SIROCCO.

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from the warmer to the colder, in the upper regions of the atmosphere—will continue to flow until the equilibrium is restored. Changes of temperature, although the prime cause of all winds, are commonly considered as bringing about changes of barometric pressure as well as changes of the specific gravity of the air; in reality, however, these are but secondary causes.

Winds are classified as constant, periodical, and variable, and are named according to the direction from which they come. To the first named belong the trade winds, which blow unceasingly from northeast to southwest in the northern hemisphere, and from southeast to northwest in the southern hemisphere, their area of operation extending from about 30° N to 30° S, with a belt of calms between, commonly known as *doldrums*.

The name *trade winds* was given to these winds on account of their steadiness and constancy, as well as for the great service they render to commerce and navigation. For centuries the trade winds were a puzzle, both to the meteorologist and the navigator. To Columbus, on his first voyage across the Atlantic, they were indirectly a source of trouble; the crews of his ships, believing it impossible to return home on account of the wind blowing constantly from the east, revolted several times, demanding an immediate abandonment of the voyage, but Columbus always succeeded in quieting them. Had Columbus, after the discovery of the New World, not been careful enough to avoid the trade winds by steering north before he turned eastward, he would assuredly never have found his way back to Spain. His vessels being badly provisioned and defective in construction, he and his crew would have perished of hunger in the vast regions of the trade winds.

The astronomer Halley was the first to suggest an explanation of the trade winds, and his theory, with a slight modification, is now accepted as correct. This explanation, briefly told, is as follows: When the portion of the earth's surface that is heated is a whole zone, as in the case of the tropics, a surface wind will set in towards the equator from both sides. These winds, being united at the equator, will then ascend and flow separately as upper currents in opposite directions; hence, a surface current will flow from the higher latitudes towards the equator, and an upper current from the equator in the direction of the poles. If, then, the earth were at rest, a north wind would prevail in the northern half of the torrid zone and a south wind in the southern half. But these directions are modified by the earth's rotation. During their movement from the poles they pass gradually by the parallels, the diameters, and, consequently, the rotary speed of which progressively increase. If their absolute velocity does not diminish, they will apparently move towards the west, and their seeming direction will be from northeast to southwest, which is, in fact, the general direction of the trade winds in the northern hemisphere. A similar result follows in the southern hemisphere; the wind there, coming from the south, is influenced by two forces—one drawing it north, the other drawing it west—and will, by the law of the composition of forces, take an intermediate direction and blow from southeast towards the northwest. All observations confirm this reasoning.

The doldrums, or calm regions, already mentioned, extend across the Atlantic and Pacific, their general direction being parallel to the equator. It marks the meeting ground of the north and the south trade winds, where they mutually neutralize each other. These calm regions occupy very different positions at the close of the winter months than at the end of the summer months. They never cross the equator in the Atlantic Ocean. In the spring the centers of these regions are only 1° or 2° north of the equator, while in the summer they often rise to latitude 9° or 10° N. These changes are directly influenced by the sun, advancing with that luminary to the northward during the summer, and retreating with it during the early winter months. The doldrums are always dreaded by the crew of a sailing ship about to cross the equator; for they know that the favorable wind that has brought them thus far will gradually fail and finally disappear altogether. In many instances ships have been detained in these calm regions for weeks, in a state of painful helplessness, the crew being unable to do anything but patiently wait for a wind to fill their flapping sails. The water all around them resembles a vast sheet of ice, slowly rising and falling with the monotonous motion of the ocean; while above, Old Sol unmercifully throws his rays vertically down upon the deck.

In connection with the origin of the trade winds, the writer once, on asking an old Italian sailor what he considered the cause of these peculiar winds, received the following

curious reply: "Before Columbus started on his famous voyage of discovery he paid a visit to a noted fortune teller at Naples, who had the reputation of being possessed of extraordinary powers. He asked her what sacrifice should be made in order to insure favorable winds on his coming voyage. Columbus, in accordance with the custom then prevailing, wore luxuriant hair, of which he was very proud. He was told that this hair would be the price of his success. After some hesitation Columbus consented to part with it; the sacrifice was made, and in return the fortune teller promised that favorable winds would blow toward the west as many days as there were hairs on his head."

Next to the trade winds the monsoons are undoubtedly the most noteworthy. The term *monsoon*, derived from the Arabic word *mawsim*, meaning "time or season" of the year, is applied to the prevailing winds in the Indian Ocean that blow from the southwest from April to October, and from the northeast, or opposite direction, from October to April. The monsoon, like the trade winds, is caused by the inequality of heat at different regions, as well as by the rotation of the earth. Had the equatorial regions been covered exclusively with water, the trade winds would have been the same all around the globe. Such, however, is not the case; in Southern Asia large tracts of land stretch into the tropics, giving rise to the extensive atmospheric disturbances for which those parts of the earth are so remarkable. During the summer, when the sun is north of the equator, the south of Asia and the north of Africa become heated to a much greater degree than the Indian Ocean, which in its turn is warmer than Australia and South Africa. Hence, as the heated air of Southern Asia expands and rises, and the colder air from the south flows in to take its place, a general movement of the atmosphere of the Indian Ocean sets in towards the north, thus giving a southerly direction to the wind. But, as the wind comes from parts of the earth that revolve more quickly, and flows to those that revolve more slowly, a direction towards the east is communicated to it. The combination of these two directions results in the southwest monsoon, which accordingly prevails there in summer. Again, when the sun is south of the equator during the winter months, the southern part of Asia is colder than South Africa. This causes a general movement of the atmosphere from the north towards the south, and by the rotary motion of the earth a westerly direction is imparted to it, thus creating the northeast monsoon. Since this direction is the same as the ordinary trade wind, it simply tends to increase the velocity of the latter. As a consequence, we find that, while the southeast trade winds prevail throughout the year on the south side of the equator, owing to the absence of large tracts of land in those regions of the earth, the north side of the equator is visited in summer by the southwest monsoon and in the winter by the northeast monsoon. About the month of April the northeast monsoon changes into the southwest, and about October the southwest changes into the northeast. These changes are always marked by variable winds, which alternate between dead calms and furious hurricanes.

FIG. 2.—THE PAMPERO.

Among variable winds, those prevailing on the deserts of Africa and Arabia are perhaps

the most remarkable, on account of their extreme dryness and intense heat. In Arabia and Western Asia this wind is known as the *simoom*, signifying "hot, poisonous, or dangerous," while in Egypt it is called *khamsin*, meaning "fifty," because it lasts that number of days, from the end of April to the time of the inundation of the Nile. In Sicily, South Italy, and adjoining districts, it is called the *sirocco*, and by the inhabitants is considered poisonous. However this may be, it certainly exercises an unhealthy influence on the regions through which it passes, and is especially dangerous to those that do not know how to protect themselves.

On the approach of a simoom a peculiar haze obscures the sky, and a black spot is seen to rise in the horizon, which rapidly grows larger and larger. As soon as the first gust of wind arrives, birds and other animals seem greatly alarmed, and fly off affrighted to seek shelter wherever it can be had. The Arab usually throws himself on the ground, after having covered his face to protect it from the flying sand, and lies face downward until the fury of the storm is over. To caravans crossing the deserts the simoom is the most dangerous thing that can be encountered, and the destruction of thousands of human lives is said to be due to this wind. In 1805 a simoom buried in the sand a whole caravan, causing the death of 2,000 men and 1,800 camels. Fig. 1 represents a photograph taken near Cape Spartivento, South Italy, showing the general appearance of the sky preceding the approach of a sirocco.

Another wind, remarkable for its dryness, is the *puna*, a mountain wind that blows in a region of Peru between the two great chains of the Andes. This wind is a continuation of the trade wind, which, after having crossed the lofty range of the Cordilleras, is cooled and parched to an extent that has perhaps no parallel in any other country of the world. Its drying qualities are so excessive that the bodies of dead animals exposed to it are very soon turned into mummies. According to Prescott, it was in this district that the ancient inhabitants of Peru preserved their dead.

A sister wind of the puna is the *pampero*, which blows from the Andes across the pampas of the Argentine Republic towards the Atlantic coast. This is also a very dry wind, frequently darkening the sky with clouds of dust and sand, and drying up the vegetation of the pampas to a considerable extent. It often carries dust and insects hundreds of miles out to sea. On one occasion the writer picked up several grasshoppers on the deck of a small vessel, at a distance of more than 150 miles from the Argentine coast; they had been carried out by a pampero, but their long seaward trip did not seem to have produced any ill effects. In Fig. 2 is shown a reproduction of a photograph taken at San Pedro, Province of Santa Fé, Argentine, about ten minutes before the arrival of a pampero. After it had passed, the trees and bushes shown in the picture were uprooted and carried several miles away from the scene.

On the south coast of Europe, north winds are notorious for their violence. They are caused by the great difference between the temperature of the Alps, the Mediterranean Sea, and Africa. Of these winds the most noted is the *bora*, which means "furious tempest." The bora is greatly dreaded in the upper part of the Gulf of Venice, where it rushes down from the whole line of the Julian Alps with such irresistible fury and suddenness that not only a number of vessels are sacrificed but entire districts of the shore are rendered nearly uninhabitable by the destructive effects of this wind on the vegetation. No sign or warning of any kind is given of the approach of the bora, which usually takes place a couple of hours after sunset. The only thing indicating its near presence is a big drop of the atmospheric pressure about a quarter of an hour before the storm comes.

Last but not least are the West Indian *cyclones* that sometimes ravage our shores and do great damage to shipping along the coast. Their origin is generally traced to the inner limit of the zone of trade winds, or to the regions of doldrums, where the heated air rises and becomes disseminated in the upper strata of the atmosphere, and in a direction contrary to that of the trade winds. Their rotary motion is probably due to the encounter of two currents of air moving in opposite directions.

The most terrible cyclone of modern times is probably that which occurred on August 8th of this year, in and around the island of Puerto Rico. This cyclone seems to have embodied all the horrible features that attend a phenomenon of this kind. Its greatest velocity occurred shortly after noon on that day, when records were made that prove this cyclone to have been the most severe within the past seventy-five years. It practically ruined the whole island of Puerto Rico, flooding the towns, blowing

down trees and houses, and burying hundreds of persons beneath the ruins, while thousands of families were made destitute and homeless.

Wind, though dangerous at times, is, however, a blessing to the world. Without it the atmosphere would remain motionless—a receptacle for all kinds of poisonous and deleterious matter. By its agency and unceasing effort towards an equilibrium, an immense circulation is established that sweeps away unhealthy exhalations, substituting for heat a refreshing coolness, and replacing cold by the warmth of spring. Besides this, its aid to commerce and navigation is invaluable.

ELEMENTS OF ARCHITECTURAL DESIGN.

W. Scott-Collins.

PROPORTIONS OF THE GREEK AND ROMAN ORDERS—DRAWING THE ENTASIS OF A SHAFT. GREEK AND ROMAN MOLDINGS.

IN PROPORTIONING the Greek and Roman orders, a uniform standard of measurement was adopted, so that the several parts of the order might be arranged in perfect ratio. This standard consists of *modules* and *parts*. A module is the semidiameter of the column, measured at the base, and each module is divided into 30 equal parts. Each diameter, therefore, is equal to 2 modules, or 60 parts.

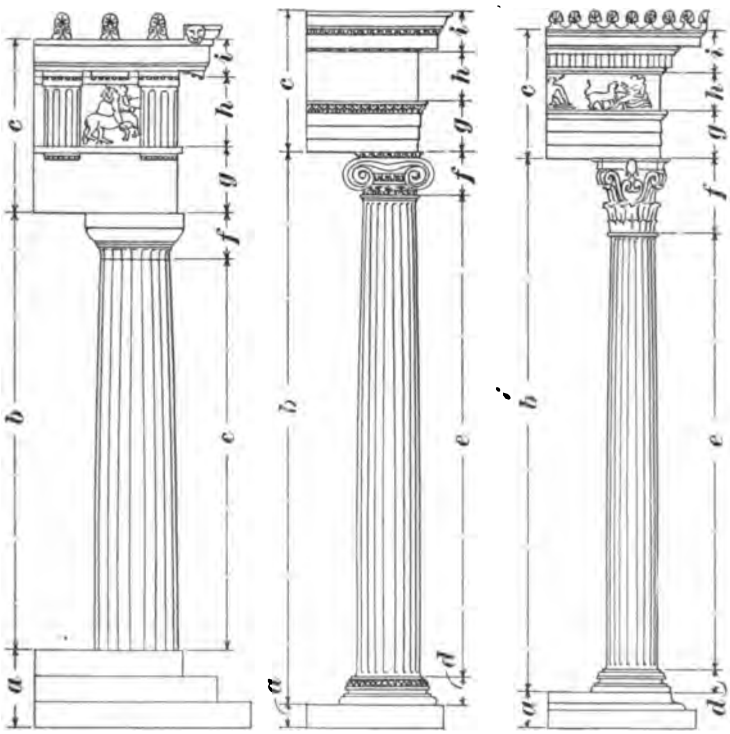

FIG. 1.

In Fig. 1 is shown a diagram of the Greek orders, after measured drawings by acknowledged authorities, and drawn to a uniform altitude. *A* is an example of pure Doric,

from the Portico of the Parthenon, at Athens. *B* is the Ionic, and is taken from the North Porch of the Erechtheum, while *C* is the Corinthian, after the monument of Lysicrates. In each example *a* is the stylobate, or base; *b* is the column; and *c* is the entablature. The column of the Doric consists of a shaft and capital, the shaft resting directly on the stylobate, while the columns of the Ionic and Corinthian have a base, shaft, and capital. The entablature of each order has three divisions—the architrave, frieze, and cornice.

A comparative statement of the relative values of the divisions of each of the Greek orders is given in Table I, and is based on the module, or semidiameter, as the unit of measurement; as previously explained, a part is $\frac{1}{30}$ of this unit.

From Table I the ratio of the entablature to the column for the Doric, Ionic, and Corinthian orders is .328, .252, and .242, respectively.

The Doric was largely used by the Greeks, their most important buildings being erected in this order. The proportions vary largely in the different examples, proceeding from extreme sturdiness in the early examples to the great refinement of the Parthenon, from which the figures of the table were taken. The architrave overhangs the face of the shaft, which is always fluted. The Ionic order was used with much delicacy by the Greeks. The distinctive capital has scrolls showing on two sides only, although examples of corner scrolls, adopted by the Romans, are also found. The Corinthian order was little used by the Greeks, but the few examples of this style, and especially the one here shown, are unsurpassed for elegance and beauty.

The Romans adopted the column-and-beam system of the Greeks, and joined to it the *arch* and *vault*. The union of the two elements of *arch* and *beam* is the keynote of the Roman style. In this style the orders were

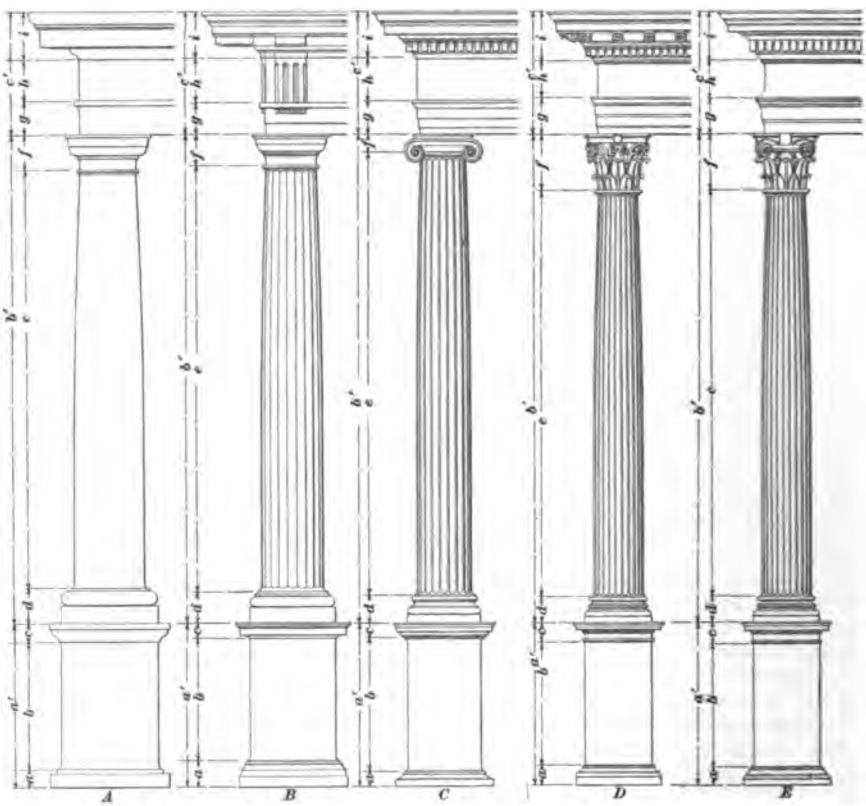

FIG. 2.

used more for decoration than for construction, and were *superposed*, or set one upon the other, dividing the buildings into stories.

The five Roman orders are shown in Fig. 2.

TABLE I.

GREEK ORDERS.

Title.	Height of Column.							
	Base *d.*		Shaft *e.*		Cap. *f.*		Total.	
	m	p	m	p	m	p	m	p
Doric	0	0	10	$2\frac{1}{2}$	0	$27\frac{1}{2}$	11	0
Ionic	0	$23\frac{5}{8}$	15	$22\frac{7}{8}$	1	$13\frac{1}{2}$	18	0
Corinthian	0	$22\frac{1}{3}$	16	$12\frac{1}{6}$	2	$25\frac{1}{2}$	20	0

Title.	Height of Entablature.							
	Arch *g.*		Frieze *h.*		Cornice *i.*		Total.	
	m	p	m	p	m	p	m	p
Doric	1	$12\frac{3}{8}$	1	$12\frac{3}{8}$	*	23	3	$18\frac{4}{15}$
Ionic	1	$20\frac{3}{4}$	1	$17\frac{3}{4}$	1	$7\frac{5}{8}$	4	$16\frac{1}{10}$
Corinthian	1	$22\frac{1}{2}$	1	14	1	$18\frac{1}{2}$	4	25

* Exclusive of the crowning member on the pediment, which is 9 parts high.

A is the Tuscan; *B*, the Doric; *C*, the Ionic; *D*, the Corinthian; and *E*, the Composite. In each of these, a', b', and c' represent the pedestal, column, and entablature, respectively. For comparison, the relative values of the lower diameters of the shafts, when the orders are profiled to a uniform total height of 31 ft. 8 in., are given in Table II.

TABLE II.

ROMAN ORDERS.

With Uniform Altitude = 31 ft. 8 in.

Title.	Index Letter on Fig. 2.	Lower Diameter of Shaft.	
		With Pedestal.	Without Pedestal.
Tuscan	*A*	2 ft. $10\frac{1}{4}$ in.	3 ft. $7\frac{1}{16}$ in.
Doric	*B*	2 ft. 6 in.	3 ft. 2 in.
Ionic	*C*	2 ft. $2\frac{5}{8}$ in.	2 ft. $9\frac{3}{4}$ in.
Corinthian	*D*	2 ft. 0 in.	2 ft. $6\frac{2}{3}$ in.
Composite	*E*	2 ft. 0 in.	2 ft. $6\frac{2}{3}$ in.

Table III gives the relative measurements, with respect to the module, or semidiameter of the shaft, for proportioning the Roman orders, and is valuable for consultation when preparing preliminary designs, the reference letters being those shown in Fig. 2.

In connection with the Roman orders it is well to keep in mind that the pedestal is one-third, and the entablature one-fourth, the height of the column in all cases.

To find the semidiameter of the column in any order, divide the height to be occupied by the number of modules in the given order. Thus, if the given height is 23 ft. 9 in. and the order is the Ionic, *with* the pedestal, the semidiameter, or module, will be 23 ft. 9 in. $\div 28\frac{1}{2} = 10$ in.; if *without* the pedestal, the module will be 23 ft. 9 in. $\div 22\frac{1}{2} = 12\frac{2}{3}$ in. The lower one-third of the columns is cylindrical, the upper two-thirds being diminished by a conchoidal curve called the *entasis*, the reduction of the shaft at the neck in all cases being one-sixth of the lower diameter.

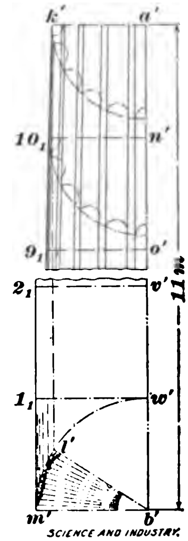

FIG. 3.

In terms of the lower diameter, the Tuscan, Doric, Ionic, Corinthian, and Composite columns are, respectively, 7, 8, 9, 10, and 10 diameters high.

The Tuscan order is a simplification of the Doric. The proportions of the Doric are less sturdy than those of the Greek prototype, and the shaft is often left unfluted. The Ionic order is more enriched than the Greek, and the capital is generally made uniform on all sides by placing the volutes anglewise. The Corinthian order was the favorite of the Romans, and was used in the largest temples. The Composite order was invented by the Romans. The capital, its distinctive feature, is a combination of the Ionic and Corinthian.

The shafts of classic columns have a curved outline called the *entasis*. In the Roman orders the lower third is straight and vertical, and the upper two-thirds is curved. The shaft of the column is diminished one-sixth of its diameter at the neck. Fig. 3, representing the curved portion of the shaft of an Ionic column, shows a method for profiling the column. Draw the center line $a'\,b'$ and the base line $m'\,b'$; also, the upper line $k'\,a'$, representing the neck of the shaft, at a distance of 11 modules above $m'\,b'$, making its length equal to the semidiameter of shaft on that line, which is 25 parts.

With b' as a center, and a radius of 1 module, describe the arc $m'w'$; through k' draw a line parallel to $a'b'$, intersecting the arc at l'. Divide the arc $m'l'$ into 11 equal parts, as shown at *1*, *2*, *3*, etc.; also, divide $a'b'$ into 11 equal parts and draw horizontal lines $1_1w'$, $2_1v'$, etc. From point *1* on the arc, draw a line parallel to $a'b'$; its intersection with the line $1_1w'$ will give one of the required points. From *2* draw a similar line to 2_1, etc. All the points being marked, draw a curve through them by means of a spline, or flexible strip.

To draw the lines of the fluting of the upper portion of the shaft, proceed as follows: From points a', n', and o' in Fig. 3, with radii equal to the semidiameter of the shaft at the section on which these points are located, describe quadrants. As the Ionic shaft has 20 flutes, divide each quadrant into 5 equal spaces of 18° each by means of the protractor; from these points, which will be the centers of the flutes, with a radius equal to ⅜ of the length of arc between the centers of the flutes, describe the semicircles defining the flutes. Project the lines of the fillets between the flutes to their position on the horizontal lines $k'a'$, etc. by drawing lines parallel to the center line $a'b'$, and through the three points established for the edge of each flute draw a curved line by means of a spline.

The outlines of the Greek moldings follow the curves of the conic sections—the parabola, hyperbola, and the ellipse—and but rarely the circle. The Roman moldings are nearly always formed of circular arcs, and for this reason lack the delicacy and refinement that characterize the details of the Grecian monuments.

TABLE III.

ROMAN ORDERS.

Title.	Index Letter on Fig. 2.	Height of Pedestal.								Height of Column.								Height of Entablature.								Altitude of Orders.			
		Base a.		Dado b.		Cornice c.		Total.		Base d.		Shaft e.		Cap. f.		Total.		Arch g.		Frieze h.		Cornice i.		Total.		With Pedestal.		Without Pedestal.	
		m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p	m	p
Tuscan	*A*	0	15	3	20	0	15	4	20	0	30	12	0	0	30	14	0	0	30	1	5	1	10	3	15	22	5	17	15
Doric	*B*	0	25	4	0	0	15	5	10	0	30	14	0	0	30	16	0	0	30	1	15	1	15	4	0	25	10	20	0
Ionic	*C*	0	16⅔	4	26⅔	0	16⅔	6	0	1	2	16	8	0	20	18	0	1	7½	1	15	1	22½	4	15	28	15	22	15
Corinthian	*D*	0	25	5	0	0	25	6	20	1	2½	16	17½	2	10	20	0	1	15	1	15	2	0	5	0	31	20	25	0
Composite	*E*	0	21⅔	5	3⅓	0	25	6	20	1	2½	16	17½	2	10	20	0	1	15	1	15	2	0	5	0	31	20	25	0

A POETIC PROTEST.

THE British literary purists object very strenuously to the use of the word "reliable." The objection is based on the fact that "rely" cannot stand alone without the preposition "on," which is needed to complete the sense. Dr. R. Farrar publishes in "The British Medical Journal" the following protest against the growing use of this word:

"I quite admit—my worthy friend—the English language pliable,
A very useful tendency, the fact is undeniable;
But no convenience can excuse that odious word 'reliable.'
I fear the foul abortion shows signs of being viable.
Yet, ere we grant the creature life, let's think to what we're liable.
A thrilling 'shilling shocker' will be advertised as cryable,
And a gentle maiden's sorrows be versified as sighable,
If we weakly grant admittance to that hybrid word 'reliable,'
A monster whose existence is quite unjustifiable.
A purchasable picture will be catalogued as buyable,
A marriage knot be registered a ligature untiable,
A legitimate experiment be spoken of as tryable;
Historians will praise immortal glory as undiable,
The poultry-monger's pigeons be ticketed as pieable,
An oath at which we say 'Oh fie!' be called henceforth Oh fiable;
E'en now the Cockney terms a trip to 'Ampstead 'Eath enjyable.
Now let us all with one consent consign it to the Diable!
And when we mean 'trustworthy' may we never say 'reliable.'"

QUESTIONS FOR STEAM ENGINEERS.

Chas. J. Mason.

SELF-EXAMINATION—LICENSE LAWS—THE MEANING OF THE NAME ENGINEER—SOMETHING ABOUT STEAM.

ANY person that has been employed in a machine shop, at the construction and erection of steam machinery, or engaged in or about a steam plant of any kind, and thinks he can safely assume the duties of an engineer, should examine himself to see if he really is capable, and has sufficient knowledge—of the right kind—before assuming such a position. In some of the states there already exists a law governing the licensing of engineers to operate and take charge of steam boilers. An applicant must present himself before a duly appointed inspector or examiner, and take an examination as to his qualifications to act as an engineer. Should he fail to pass, and still accept the position offered him, he is liable to be severely punished.

There are some states in the Union that have no license law, and an employer can engage almost any person he cares to. Of course, a man engaged in that way may or may not be competent. But, in many cases, any person that claims to be an engineer and can show that he has worked in such and such a plant is engaged, and in time is found to be incompetent. A man may take charge of a plant that is in fair shape, and by simply *not* touching anything, except the starting bar and throttle valve, may continue in that position for quite a time; when a breakdown occurs (which possibly could have been prevented had an engineer been in charge) he knows not what to do, nor can he give directions to those that may be about him. Such a man, whom I call an "engine driver," will refer you to his "time of service"; he will tell you "nothing ever happened like that before," and give such like explanation.

Now, whether in a place subject to license laws or not, it should make no difference to a man that wishes to hold an engineer's position; he should qualify himself for that position by experience and study. Simply by "putting in" so many hours a day doing a certain kind of work in a plant, and then going home to forget all about it till the next day, will not aid him very much. Steam engineering is not like a trade in which a boy is placed for a number of years, doing certain things every day, according to instruction given him by a foreman, or leading man, and where he need not bother his head after he leaves the shop. On the contrary, one must bother his head about things that he will not learn in a machine shop or engine room, if he wishes to be even an "ordinary" steam engineer. In short, there is a great difference between an engine driver and an engineer; the engine driver may become an engineer, if he wants to, by learning the ins and outs of his business, but he cannot become one by merely being contented with starting and stopping his engine, and performing a few other routine duties.

While it would be of little use to give a student a list of questions and answers to learn by rote, as a schoolboy would learn a "piece," yet, by actually studying the things suggested by such questions, much knowledge may be acquired. The mere fact of having learned by heart the answers to certain set questions is of no permanent benefit, not even if such a person actually managed to pass the examination given him, for he may have to go through another at some future time, and get an entirely different set of questions. If he had studied the principles and the elements of the questions, he would be able to give a satisfactory answer, no matter in what form the question would be given.

The object of this article is to give questions and answers, such as would be asked at an examination, and to explain as much as possible of the different subjects introduced. Of course, it is not the intention to give a deep and exhaustive explanation of all, but we hope to give sufficient information to make you desirous of seeking further.

It must be borne in mind that no amount of mere reading of anything is of great value. You must read, and think over what has been read, again and again—turn and twist it, mentally, into every conceivable shape and form. Argue with yourself about it, make diagrams of it for yourself, and try to find out all there is in it. You will be surprised at the task before you. Many times you will be obliged to stop at some point in a problem, owing to your

ideas becoming confused; well, stop, drop it for a time, but go at it again. Each time you resume it becomes easier—clearer. Of course, all this is hard work, and while there are ways and means whereby hard work is made easier, yet for all this, even the easy ways must be worked at diligently and hard if success is desired.

Engineering is not an easy profession. Those who have entered it with that idea have made a mistake, which will be brought home to them day by day. They see others go by them to better positions, and wonder how it can be. They blame everybody concerned—except themselves. In many cases men fail simply because they will not take the trouble to fit themselves for better places. If such places could be obtained easily then they would be sought for eagerly. Therefore, readers, do not be content with holding a position where you have to fire a boiler, and see that a certain quantity of water is kept in it, or start and stop an engine every day, and keep it oiled, and occasionally adjust the different parts. All this is very essential, and requires to be done right and well; but it is only a part of what you should know and do. You should not only know how to do these and other things, but you should inquire why they are done, what would be the result if they were not done, and how soon such results would appear.

Such thoughts as these should constantly occupy your mind. One thought will suggest another and another in turn, and you will find in time that, when you become fully aware of the mighty and dangerous forces over which you have control, you will be obliged to "take your thoughts home with you," in order to cope with, or prevent, any mishap that is liable to attack the machinery under your care. This is what makes an engineer of you in reality. You will be living, to a great extent, in the future. The present condition of your plant is the result of thought of some time past. So it is plain that an engineer must be a thinking man.

In presenting the following questions and answers, the aim is not to deluge the reader with a great number, such as can be found in different books published, called catechisms, but rather a few, which in turn will suggest others, and thereby cause you to look them up yourselves. In studying from a catechism, a person will naturally start in to commit to memory the questions and answers as given; should this question be given in a different form, or different words be used, he will be almost sure to fail, simply because he had never thought of the subject in any other way than that given him. If he studies the elements and principles and thoroughly understands them, it can hardly be possible for him to fail, even though he has never seen any set form of questions.

There is another matter in connection with the subject of this article that deserves mention, and that is of textbooks that engineers have in their possession and read and study. Having books is one thing, and knowing how to use them is another. This is an art in itself, and requires to be studied. If men would learn just how to study books, before actually taking up the specific subject, they would save themselves a lot of time and trouble. For instance, how much easier would it be for the student if he understood the plan of the work he is studying. Every author has a preconceived plan upon which his work is based and constructed, and in order that the greatest benefit may be derived from the study of such work, it is essential that the plan be known to the student, so that he can follow the ideas of the writer, as the writer intended they should be understood. How many engineers read the "preface" to their books? Again, how many know the number of parts their books are divided into, and where to find a certain subject upon which they may want information? As an example, it is required to make a calculation in which the "Table of Properties of Saturated Steam" is to be used. Where is this table to be found? You think you have come across it somewhere, but just when you want it you don't know where to find it, without taking down a lot of books and hunting through each until found; and when the table is found, can you use it? Do you know how to apply the figures in the different columns in the table? So you see that, although you may have all the books desirable, you may not know the plan of any nor how to use them. It would appear from the foregoing that there is much to think of and to learn, not necessarily by heart, but by observation and thought. It is not necessary to learn the steam table, just mentioned, by heart—no one is expected to do so, but he is expected to know where it can be found, and how to use it—and, by frequently or occasionally using the table, he will, without making any attempt to learn by heart, actually know it better than if he had committed it to memory.

One of the first questions an engineer would be asked is, "What is steam?" A simple answer to which is, "It is an invisible elastic fluid, generated from water, by the application of heat." Here, reader, is material for study and food for thought. The subject of steam alone would occupy many pages; consequently, we can only make a few remarks and offer a few suggestions. Now, let us look into the answer of the question just given, "It is an invisible elastic fluid, generated from water, by the application of heat." Many applicants would be satisfied with barely learning this answer. Suppose the examiner should next ask, "How do you know it is an *invisible* fluid?" This may be a poser for you, as you never thought of that; the book you learned from didn't have that question in it, and so the only answer you can make is that "the book says so." Should this question be asked of a man that had never studied, and had not thought out any problems for himself, he would probably make answer, "I know steam *is* visible, for I have often seen it coming out of the exhaust pipe!" Well, we usually *do* call that which comes from an exhaust pipe, and also that which leaks from our glands about the engine, steam, but, technically speaking, it is not steam, but vapor.

Referring to the Standard Dictionary of 1898, we find the following: "Water changes into aqueous vapor by surface evaporation at all temperatures, but the vapor is not commonly called *steam* till it is produced in the body of the liquid by ebullition. The temperature at which this takes place increases with the pressure; at ordinary atmospheric pressure it is 212° Fahrenheit."

Just think a moment and try to find a way by which you can tell that steam is invisible. Sometimes the simplest things are not taken notice of on account of their simplicity. We are very apt to slight elementary truths in our anxiety to go into a subject deeper, either forgetting or not knowing what trouble and perplexities such a course is sure to bring. We once knew of a skilled boilermaker who held a foreman's position in the works in which he was employed, and, like all good conscientious mechanics, felt the lack of a technical education. He enrolled in a mechanical-drawing class, and, of course, the instructor began with him as he would with a schoolboy. The first night he was given straight lines to draw, simply using a pencil and triangle. At first he looked amused, and then disgusted, and finally he called the instructor over to him, and told him that he did not want to spend his time "ruling" lines like a boy at school. The instructor tried to assure him that it was absolutely necessary that he should start at the beginning, and smilingly told him that even now he could not draw what a draftsman calls a straight line, and called his attention to the imperfections of those he had tried to draw. This man expected that he could be taught to draw the different parts of a boiler, without even having a knowledge of the use of the different instruments employed! The first lessons in geometrical drawing were too simple for a man of his mechanical knowledge! He never came to the class again.

To return to the question of steam being invisible: did it ever occur to you to look at your boiler-gauge glass and think of what you saw there other than water? What do you see in the space above the water-line? Why, nothing at all. Is there, then, nothing in that part of the glass? Yes, there is steam, if your gauge is in working order, as we now assume it to be, and yet it cannot be seen. There is no doubt that many reading this will be inclined to smile at the simplicity of the last few remarks, but it is nevertheless true that there are many men in charge of steam plants that do not think deeply enough to draw conclusions from things they see around them day after day. It brings to mind the old saying, in which there is great meaning, "Eyes and no eyes, or the art of seeing," and there are many such people, who, though their eyes look at different objects, see nothing.

There is another thought suggested by the answer to the question under consideration, that of the steam being an elastic fluid. Aside from perhaps seeing this answer given in textbooks, how do you know it is elastic? What leads you to think it is elastic, apart from the fact of it being part of the answer? Perhaps you have not thought of this before, and a desire may now come to you to know more about steam, and where such knowledge can be obtained. We will note two cases only, at this time, in which the elasticity, or expansion, of steam is illustrated. First, there is the expansion line of an indicator diagram, which shows the steam following the piston *after* the valve has been closed; this clearly shows that the steam does expand, or increases in volume, as the piston advances. Of course, a reduction of *pressure* is taking place simultaneously with expansion. It is just this expansion that

makes steam so valuable to us, and also economical. The second illustration is that of the steam table, before mentioned. By giving a little study to this table, much about steam can be learned. This table has been compiled from actual knowledge of steam, and also experiments with it; it is authentic, and, for all purposes for which it is used, is as correct as need be. It can be seen, by comparing the different columns of this table with one another, that steam is elastic. It is known that 1 cubic inch of water, turned into steam at the atmospheric pressure, will expand to a volume of, approximately, 1 cubic foot. The foregoing is by no means all that can be learned about the elastic properties of steam, but space does not permit a fuller explanation, and, indeed, it is not the intention of this article to make one, but rather to cause the reader to follow out the train of thought suggested.

In the concluding part of the answer, "generated from water by the application of heat," how is the heat applied to the water, and, what is heat? There is no doubt that most men, who are concerned with steam boilers, know that the heat from the glowing fire in the furnace radiates, and is conducted through the metal plates and tubes of the boiler to the water contained therein; thus, the heat is applied to the water by radiation, conduction, and convection—convection being the means by which circulation is maintained. But, what is heat? What causes heat? What is the relation existing between *heat* and the work it performs? Here, then, is material for study for some time to come; search it out, reader, and follow it up; many interesting things will be presented to you in the course of your reading of the subjects suggested above.

We will conclude this part by stating that heat is considered to be a mode of motion—motion of the *particles* of which the body is composed; these particles are termed molecules. Heat may be caused by rubbing two pieces of ice together to such an extent as to cause the ice to melt. Heat is a form of energy, and heat and mechanical work are convertible into each other, and there exists an exact and invariable relation between them.

(*To be Continued.*)

INTERCOMMUNICATING TELEPHONE SYSTEM.

H. S. Webb.

MAGNETO CALL INTERCOMMUNICATING SET—COMMON BATTERY CALL—HINTS FOR WIRING AND CONNECTING.

IT IS the purpose of this article to explain the installation and operation of an intercommunicating telephone system that can be installed by any man or boy who is able to run electric-bell wires. It is not necessary that he should understand the inside connections of the telephones or even of the intercommunicating switches.

By an intercommunicating telephone system is meant one having three or more telephones connected to the same system of wiring in such a manner that any telephone may be used to call up and converse with a person at any other telephone, by the use of a simple switch at the first station, and without requiring any central station switchboard whatever. For this purpose there are two general classes of telephone apparatus that may be used; one, in which a magneto generator, that is, a small hand-operated dynamo, is used to ring the telephone bells; the other, in which a battery, located at some convenient place, has its circuit closed by a push-button switch at the original calling telephone station, in order to ring the bell at the desired station.

In the first class, the ordinary telephone magneto generators and polarized bells are used, no battery for signaling purposes being necessary. This system requires one more wire throughout the building in which the telephones are located than there are telephones. For instance, if there are nine telephones, ten lines are required. Where a common battery is used for ringing the bells, a simple direct-current vibrating bell is used in place of the more expensive polarized bell, and no magneto generator is required at all. This system, however, requires two more wires throughout the building than there are

telephones, thus using eleven wires for nine stations. An intercommunicating system is quite practical and satisfactory up to ten or even twenty stations; beyond that the large number of wires running through all stations makes the system quite complicated and expensive, especially when the stations are some distance apart. For a large number of stations well scattered a simple central-station switchboard system would be preferable.

The system using the magneto generator for calling up another station will be described first. Fig. 1 shows a diagram for four stations, but the system can, of course, be extended to include any larger number. T_1, T_2, T_3, T_4 are the usual telephone sets, as sold by the manufacturers, complete with transmitter, induction coil, receiver, hook switch, local microphone battery, magneto generator, and polarized bell. At each station that point of the switch that corresponds in number to that particular station is not connected with any other point or wire, although the connecting arm of the switch normally rests upon it. That is, s_1 should normally rest upon contact *1*, s_2 upon contact *2*, and so on at all stations. This is the normal, or home, position of the arm, to which it should always be returned when through using the telephone. To insure uniformity at all instruments, the home position should be the first one on the left, as shown at each station.

If all the switches s_1, s_2, s_3, and s_4 are in their normal positions, i. e., on their home contacts, it will be found that the circuit of each instrument is open at its own contact point on every selective switch, and no bell can be rung by turning any generator handle. If Station 2 desires to call Station 1, it will be necessary to first move the switch arm s_2 at Station 2 to contact point *1*. If the generator at Station 2 is turned before doing this, neither bell at Station 2 nor any other bell will ring, supposing, of course, that all switch arms are resting on their home positions. This silence will indicate to the person at Station 2 that he has not turned his switch at all. If, however, he first turns his switch s_2 to point *1*, and then operates his generator, both his bell and the bell at Station 1 will ring, but no others. The path

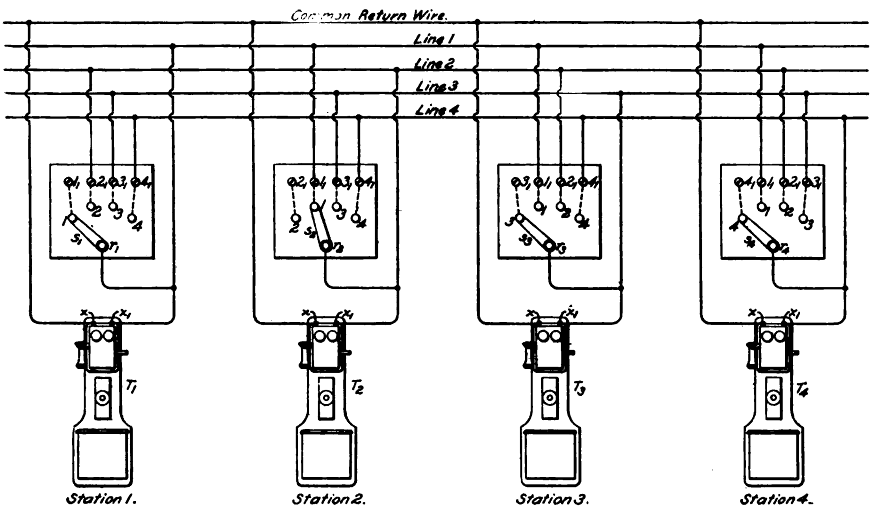

FIG. 1.

of this ringing current will be as follows: From the generator at Station 2 to its binding post x_1, to switch s_2, to binding post 1_1, line *1*, binding post x_1, bell, and binding post x at Station 1, to the common return wire, to bell and generator at Station 2. Thus both these bells will ring; but none of the other bells will ring because their circuits are open. Similarly, by turning switch s_2 to point *3* or *4*, Station 3 or 4 will be called up. In the same manner, a party at any station can, by turning the switch there to the proper position, ring up any desired station. Suppose the person at Station 2 goes away from his telephone without returning the switch from point *1* to its home position; let us see what will happen. It is quite evident that Station 1 can ring up Station 2 without touching his switch, and if he does

move his switch to point *2* he will still ring only Station 2. If Station 1 desires to call up Station 3, and moves his switch s_1 to point *3* and turns his generator, both telephones T_2 and T_3, being in parallel with each other, will cause the current from the generator at Station 1 to divide between them, and, therefore, in addition to the bell at the home station, those at Stations 2 and 3 will also ring. If both parties answer, some confusion may arise, but Station 1 can easily dismiss the one not wanted and continue his conversation with Station 3.

If, as before, Station 2 leaves his switch arm s_2 on point *1*, and Station 4 desires to call up Station 3, the only bells to ring, when Station 4 puts his switch s_4 on point *3* and turns his generator, will be his own and that at Station 3. This can be determined by the reader himself, by tracing out the closed circuit. If the number of stations were larger than given in the figure, it could be shown that if one switch is left on some point other than its home position, say, for instance, that switch s_2 is on contact *1*, then any station other than Station 1 or Station 2 can ring up any desired station except Station 1 or 2 without calling up any other. But should Station 4 attempt to call up Station 1 or 2, the bells at both Stations 1 and 2 will ring.

If, while Station 1 is ringing up Station 2, Station 3 can also call up Station 4 without interfering in any way with Station 1 and Station 2, it follows that Stations 1 and 2 can be talking together at the same time that Station 3 and Station 4 are conversing. So, on a system having a large number of stations, all the telephones can be in use at the same time in sets of two. Of course this will not warrant putting too many stations on one system, for other reasons. Furthermore, the telephones can never be left in a position entirely useless on account of the position of the hand switch.

Some manufacturers have a device whereby hanging up the receivers cause the hook switches to return the selective switches s_1, s_2, s_3, and s_4 to their home positions. This, although not necessary by any means, is quite desirable, if the device is reliable.

The telephones, switches, and the wires running through the building should be connected exactly as shown in Fig. 1. The x binding posts at the top of the telephones are connected to the common return wire, and the x_1 binding posts are connected to the pivots r_1, r_2, r_3, and r_4 of the switch arms s_1, s_2, s_3, and s_4, respectively, and also to their own particular line wires. That is, at Station 1, x_1 is connected to line *1*; at Station 2, x_1 is connected to line *2*; and so on at all stations. The binding posts 2_1, 3_1, and 4_1, at Station 1, are connected to lines *2*, *3*, and *4*, respectively. Similarly, at Station 2, binding posts 1_1, 3_1, and 4_1 are connected to lines *1*, *3*, and *4*, respectively. It should be noted that binding post 1_1, at Station 1; binding post 2_1, at Station 2; 3_1, at Station 3; and 4_1, at Station 4, are not connected to anything.

The system using a common battery for ringing up the telephone stations is shown in Fig. 2. The connections are very much the same as for the magneto-generator call system shown in Fig. 1, and the manner in which the system operates is the same, except that instead of turning a generator handle a push-button switch is pressed in order to ring the bell at another station. The push-button switch is so made that it normally connects its pivot c_1 with a contact point a_1, but when depressed it connects the pivot c_1 with the contact point b_1. The common battery for calling or ringing purposes is connected at any convenient point between the common return and the battery wires. When the push buttons at all stations are in their normal positions against the upper contacts, the common battery is on open circuit. If, however, one push is depressed, say P_2, and the switch arm s_2 is on point *1*, then current will flow from the common battery *C. B.*, through the battery wire, contact b_2, pivot c_2, binding post x, telephone T_2, binding post x_1, pivot r_2, arm s_2, contact point *1*, binding post 1_1, line *1*, and at Station 1 through binding post x_1, telephone T_1, binding post x, pivot c_1, contact a_1, common battery wire, and, finally, back to the common battery *C. B.* Thus, bells at both Stations 1 and 2 will ring as long as the push button P_2 is held down.

The telephone instruments for the common battery-call system should cost at least three or four dollars less per station, and, although one extra common calling battery and one extra line will be required, it is the cheaper to install, and, if the batteries are properly attended to, should give very satisfactory service. The magneto-generator and polarized-bell system will require less attention, and for that reason is more desirable. The latter class will cost for a six-station system about twelve or thirteen dollars per station, including a simple six-point switch; i. e., a switch like the one shown for calling any one of the six stations. This does not, of course, include the cost of wire and labor for

installing. Additional points for additional stations will not cost over twenty cents per point per station, thus making each instrument for a ten-station system cost, at twenty cents per point, eighty cents more than for the six-station system. The wiring will cost about one-half as much more.

The telephones can be bought complete, so that all that is necessary is to connect the wires running throughout the building to the proper binding posts on the telephone boxes. If ordinary telephones without the selective switches are used, and the switches obtained separately, it should not be difficult, with the aid of the diagram and explanations given in this article, to connect them together properly. Where the common call-battery system is to be installed and instruments not especially made for the intercommunicating system are to be used, an extra push button as shown in the diagram of this system will be required in addition to the selective switch.

All the line and common return wires should start at one station and run by the shortest path to all the other stations in proper order. The wires from the binding posts at each station should be tapped on, that is, connected to the main wires without cutting the latter at all. The joints between wires should be soldered and covered with insulating tape, and the free ends of the main wires, if any are left, should be carefully insulated from each other by wrapping each one separately with tape. For soldering the wires, do not use acid, but resin or some other non-corrosive flux.

The wire to be used for interior work had better be No. 18 B. & S. insulated copper, although No. 20 might be used if there is no danger of it being injured mechanically, for it is not strong and will break rather easily if nicked. The insulation of the so-called "office wire" is superior to that of "annunciator" wire, but the latter is cheaper and will do where not exposed too much. If a first-class job is desirable and expense is not so important an item, use No. 16 or No. 18 B. & S. damp-proof office wire. For outdoors, where each wire is to be supported on a separate insulator, use No. 14 or 16 hard-drawn copper wire. Unless the number of stations is small, the plan of running so many bare conductors, each on a separate insulator, is not very convenient, and a lead-covered cable, supported on one or on several strong steel telegraph wires, should be used. Even for indoor use, the requisite number of wires may be obtained made up into a cable with or without a lead sheath. The cable will cost more, but will be very neat and satisfactory and require less time to install.

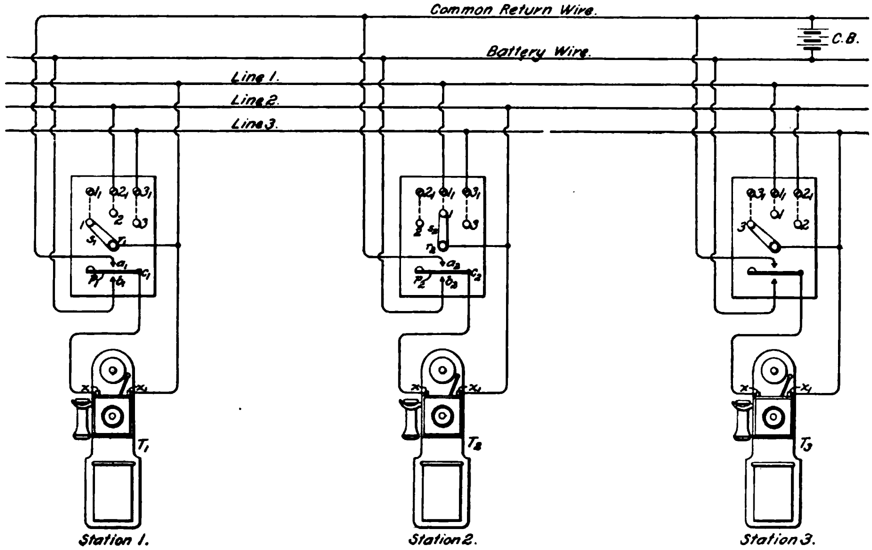

FIG. 2.

In supporting the lead-covered cable care should be taken that there is no pulling strain upon either the lead sheath or the copper conductors. The entire weight of the cable should be borne by the steel wire, from which it is suspended by means of hangers, or hooks, made for that purpose.

If each wire in the system has a different

colored insulation, it will be found to be very convenient in tracing out some particular wire from place to place. Of course, when installing a large number of telephones, this cannot always be done, but the common return and battery wires should at least be different in color from each other and from all the others.

KITCHEN BOILER CIRCULATION.

Thos. N. Thomson.

THEORY OF HOT-WATER CIRCULATION—PIPE CONNECTIONS FOR BOILER LOCATED BESIDE RANGE—CIRCULATION TO BOILER IN BASEMENT—DANGERS OF THE LATTER METHOD.

WHAT is understood by water circulation is the motion of water through a circuitous course back to the starting point. The course may be through a series of pipes, or simply through the interior of an open vessel, a tea kettle, for instance, or through the interior of a closed vessel, such as a kitchen boiler. By gravity circulation we mean that the motive power, that is, the power that moves the water and causes it to circulate, is the force of the earth's attraction, or the force of gravity, more commonly expressed by the term weight. When a body of water is increased in temperature, it expands and, consequently, occupies more space; when decreased in temperature, it contracts and occupies less space. The smaller the space a given weight of water occupies, the greater is the density of the water; and, the greater the space the same weight of water occupies, the more *tenuous*, that is to say, the less dense, will the water become. If the density of a body of water is uniform throughout, there will be no circulation, because the weight of any part of the body is equal to that of an equal volume of any other part of the same body, and hence one part cannot displace another. If, however, a certain part of the volume is increased in temperature, that part will expand (become less dense) and will flow upward, being displaced by the denser water surrounding it, for the same reason that a cork or other light body will rise when immersed in water. In any body of water having a temperature above 39.2° F., which is the point of maximum density of water, the coldest particles will fall to the bottom, and the others will take their respective positions throughout the body according to their respective densities, or temperatures, the hottest, or the least dense, being at the top.

FIG. 1.

Suppose that we partly fill a kettle with water, and apply heat to the center of its base by a flame, what will happen? Heat from the flame is absorbed by the bottom of the kettle, and conducted through its thickness to its inner surface, from which it is transmitted to that portion of water nearest it. This portion, being increased in temperature, becomes less dense, and will, consequently, rise toward the surface. The water that takes its place will in turn become heated and also rise. The water at the top is cooled by coming in contact with the atmosphere. The particles of water touching the sides of the kettle become cooled by the transmission of heat from them through the metal to the outer atmosphere. Thus, it will be understood that the particles touching the sides will descend more rapidly than the particles at any other part of the vessel. The rising of the hot water and falling of the cooler water is called circulation. In physics, this method of heat transmission is termed *convection*, and in plumbing it is usually called *local circulation*, since the entire volume of the water is within the same vessel and undivided.

Let us now suppose that the water in a cylinder has to be heated by a flame a few feet away; how can the heat of the flame be communicated to the water? We know that we can form currents by heating a part of the water, and that such currents will communicate heat by convection; consequently, we place a heater *C* over the flame, as shown in Fig. 1, so that it will be subjected to the direct heat of the fire, and

connect it by pipes D and E to the vessel. The water in C receives heat from the flame, is thus made more tenuous, and is caused to ascend in the flow pipe E and enter the vessel. Colder water enters C through the return pipe D to replace that leaving it through E. A continuous circulation is thus maintained between the vessel and the heater C, the currents flowing in the direction of the arrows. This is the principle of circulation between the ordinary kitchen boiler and the house range. The velocity of circulation depends on the difference in the mean density of the flow and the return columns, their vertical heights, and the resistance to the flow by friction, obstructions, etc. The greater the difference in density between the columns, or the greater their vertical heights, the greater will be the velocity of circulation, and the less difference in the density of the columns, or the less their vertical heights, the lower will be the velocity of the circulating currents.

Now that we understand the laws of circulation, let us consider how they are applied to the ordinary kitchen boiler and its connections to the range. Fig. 2 shows a kitchen boiler fitted up to receive hot water from the water heater B, commonly called a waterback. The boiler stores the hot water until it is drawn off at the faucets. This method of connecting a kitchen boiler to the kitchen range, and to the plumbing system is the one most commonly employed in the United States. The boiler is fed with cold water from the street main by the pipe D. The boiler being filled with water, the fire is started in the range, and the water in B, which is in direct contact with the fire, is thus heated; but as it is heated it rises in the pipe E the same as it would if it were in E, Fig. 1, and heat were applied to C. The heated water from B enters the side of the boiler at F, and immediately rises toward the top, where it remains until drawn off at a faucet through the pipe G or is displaced by warmer water. The coldest water is always at the bottom of the boiler and the hottest at the top. For this reason, the pipe G, through which the hot water is drawn, is always connected to the top of the boiler, and the pipe H, which supplies the water heater B, to the bottom. Cold water is fed to the boiler through an inner tube I, which should reach down inside the boiler to a point about 3 inches above the level of the water heater. The reason for this is that should there ever be a partial vacuum formed within D, such, for example, as may be caused by fire-engines pumping water from the city mains, there will be no danger of siphoning the water in the boiler to a point below the water heater. A small hole J in the top of the tube is usually made to admit air to D and thus break siphonic action before the water-line in the boiler falls too low.

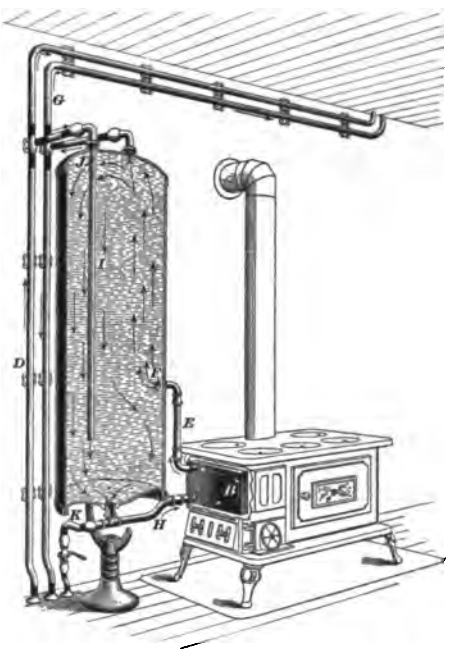

FIG. 2.

Fig. 3 shows part of a building, containing a few plumbing fixtures, house tank, and range, fitted up in a different manner. The object here is to have the hot-water storage tank a located in the basement, as shown.

We know that if the boiler and the range are connected by two pipes dropping directly from the range to the boiler, circulation will not take place between these points, because the hot water, obedient to the law of gravitation, will remain in the waterback and the cold water in the boiler. There will be no force present that will raise the cold water to the waterback, and so displace the hot water and cause it to flow down to the boiler. The water would simply remain in the waterback until part of it was converted into steam, when, by the enormous expansion of the water so changed to the gaseous state, the greater part of the hot water would be forced down the pipes that connect the waterback to the boiler, and the waterback

then being full of steam, instead of water, would soon become overheated. Such a condition is usually made manifest by snapping or hammering and rumbling sounds.

In order to obtain a force or power sufficient to cause the hot water to descend to the boiler, and thereby secure a circulation between the boiler and the range, the flow pipe *f* is extended vertically upward as far as the circumstances will allow, then returned and dropped downward to the boiler, as shown by *f* and *e* in Fig. 3.

When this system is full of water, and before a fire is started in the range, the

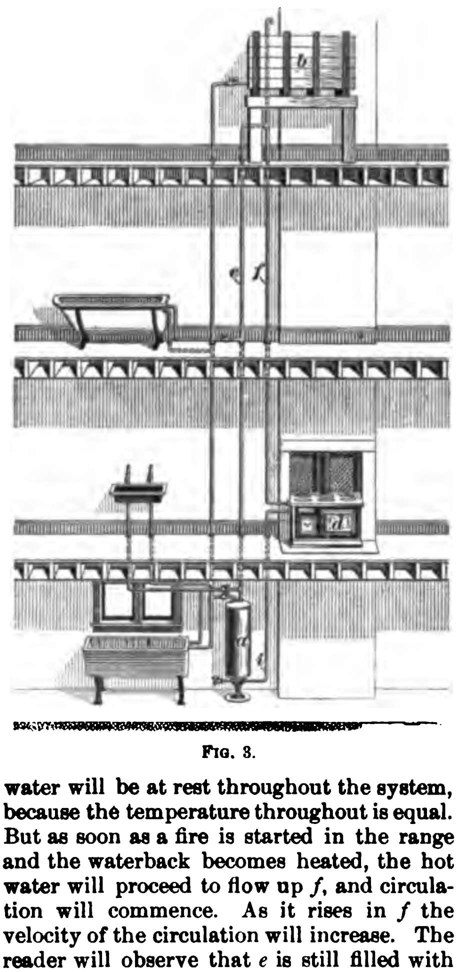

Fig. 3.

water will be at rest throughout the system, because the temperature throughout is equal. But as soon as a fire is started in the range and the waterback becomes heated, the hot water will proceed to flow up *f*, and circulation will commence. As it rises in *f* the velocity of the circulation will increase. The reader will observe that *e* is still filled with cold water, while *f* is now filled with water at a higher temperature, which we take the liberty to call hot. The density of the water in the columns *e* and *f* being unequal, it follows that the hot water will flow down *e* and take the place of the cold water, which thus falls into the boiler. The velocity of the circulation will now, however, begin to decrease, because as the hot water descends in *e* the mean density of the water in this tube will approach that of the water in *f*. The tube *e*, however, cannot attain a temperature as high as *f*, because the hot water will have given off some of its heat to the atmosphere, etc. before it travels very far; and, the lower the velocity of circulation, the more heat will be given off by a certain weight of water in traveling a given distance; consequently, the slower the circulation, the greater will be the difference between the densities of the water in the tubes *e* and *f*. It will thus be observed that circulation must take place between the range and the boiler. There is one feature in this arrangement, however, we must not leave unconsidered, which is that a certain drag is made upon the circulation by connecting the waterback feedpipe *i* to the bottom of the boiler, as shown. When the boiler is filled with hot water, the column of cold water in this pipe really forms a resistance that must be overcome by a difference in density between *e* and *f*. The effect of cold water in *i* and hot water in *a* is contrary to the effect of hot water in *f* and colder water in *e*.

Summing up, we may say that the actual effective force, which operates to circulate the water between the range and the boiler, is the mean density of the water in *f* plus the mean density of the water in *i*, minus the mean density of the water in *e*, plus the mean density of the water in the boiler.

When a system of piping similar to that shown in Fig. 3 is employed, particular care must be taken to arrange the work in such a manner that the waterback cannot be accidentally drained by shutting the water off and draining the branches for repairs. It should be so arranged that the hot water may be shut off from the fixtures without interfering with the range circulation. This can be easily accomplished by placing stopcocks where shown in the figure.

The reader must understand that, although we illustrate and describe a method of connecting up a boiler in the basement to a range above it, we do not recommend its use when it is possible to locate the boiler higher than the range. We never believe in inviting trouble, and therefore always prefer to see work installed so that there will be no doubt at all of its successful operation.

TRANSMISSION OF MOTION IN MECHANISMS

George A. Goodenough

Laws of Direct-Contact Transmission—Outlines of Gear-Teeth—Conditions of Pure Rolling—Non-Circular Rolling Wheels.

PREVIOUS articles have dealt, to some extent, with the relative motions of the various links of a mechanism, and we have seen how these motions may be investigated by means of the instantaneous centers of the system of links. So far, however, we have looked upon the links of the mechanism merely as moving bodies, without concerning ourselves with the manner in which motion is transmitted from link to link. The transmission of motion in mechanisms forms an extremely interesting part of the kinematics of machinery, and is a subject of peculiar value to the inventor or designer of machinery. It is a part of this subject that we shall consider in the present article.

In any machine or mechanism, motion is imparted to some link by an external agent; the motion of this link is transmitted to a second, and so on. When motion is thus transmitted from one link to another, it is customary to call the first link the *driver*, and the second link the *follower*. The methods employed to transmit motion from driver to follower fall into two classes: (1) that in which the motion is transmitted by direct contact between the two parts; (2) that in which the motion is transmitted by some intermediate connecting link. As examples of transmission by direct contact, we have friction gears, toothed gears, cams, etc. The intermediate connecting element of the second class may be a rigid bar, a flexible cord or belt, or a fluid column. Take, for example, the familiar steam-engine mechanism composed of the piston (and piston rod), connecting-rod, and crank. The piston in this case is the driver. Motion is imparted to it by the external force—the pressure of the steam in the cylinder—and it imparts motion to the crank and crank-shaft. The crank and attached shaft is to be considered as the follower, and the connecting-rod is the intermediate link that serves to transmit the motion.

We consider, first, the communication of motion by direct contact. Suppose a and b, Fig. 1, to be two bodies in contact at the point A, and that a is the driver. Suppose, further, that on the curve that indicates the bounding surface of a we select, at random, points B, C, etc., and on the curve of b the points B_1, C_1, etc., so that $A\,B = A_1\,B_1$, $B\,C = B_1\,C_1$, etc. Now, if the two bodies move in such a manner that the points B and B_1 coincide, then the points C and C_1, etc., the motion is pure rolling. If, on the other hand, the points of a come in contact successively with points of b, but in such a way that B falls in contact with a point nearer to or farther from A_1 than is B_1, then the motion is a mixed rolling and sliding. Let us assume, first, that the motion is pure rolling, and determine the instantaneous center of the motion of the bodies relative to each other. Let the line t be the common

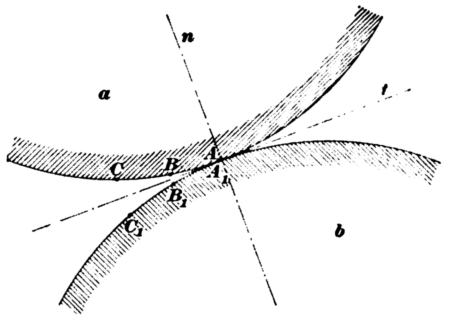

Fig. 1.

tangent to the bounding curves at the point of contact A; then the line n, passing through A and perpendicular to t, is the common *normal* to the curves. Consider the motion of the point A relative to the body b. It is evident that A cannot move relative to A_1 along the normal n, for in that case the bodies would either separate or penetrate each other. Neither can A move relative to A_1 along the tangent t, for such a motion would be sliding and would displace the points B and C so that they would not fall on B_1 and C_1. It follows that A has no motion relative to A_1, and the two points have the same velocity and are moving in the same direction. But we have seen that when two bodies have relative motion, the one point that has the same velocity, whether it is considered a point of first body or of the second body, is the instantaneous

center of the motion. Hence, the point of contact A is the instantaneous center of the motion of a relative to b, or the motion of b relative to a. The truth of this statement is almost self-evident. For, suppose the body b is at rest; then a has a motion of pure

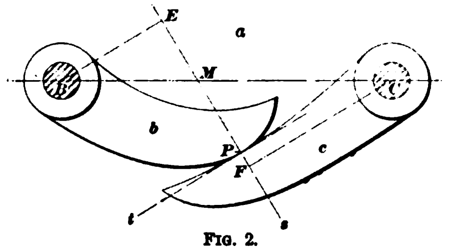

FIG. 2.

rolling. It is clear that at any instant the point of contact is the point about which the body is turning. We may, therefore, state the following as a formal proposition: *If the relative motion of two bodies is pure rolling, the instantaneous center of that motion is always the point of contact of the two bodies.*

We now consider the case of mixed rolling and sliding motion. Referring to Fig. 1, suppose the body a to remain always in contact with the body b, as it must do if it communicates motion to b. If the motion is a mixed rolling and sliding, then it is evident that the point A must move relative to the point A_1. But this motion must be in the direction of the tangent t, for if there were any component along the normal n, the bodies would either separate or penetrate. It has been shown in a previous article that the instantaneous center of the motion of a body must lie on a line drawn through any point perpendicular to the direction of motion of that point. Now, the motion of the point A is in the direction of the tangent t; hence, on the normal n, the line through A, perpendicular to t, lies the instantaneous center of the motion of a relative to b. We have, then, the following general principle: *If one body transmits motion to another by direct contact, the instantaneous center of the relative motion of the two bodies lies on the common normal passing through the point of contact.*

We can now pass to a more concrete case, in which the two bodies in contact rotate about fixed axes. Such cases are often met with in machine construction, cams and gear-wheels being familiar examples. Let b and c, Fig. 2, be two bodies rotating, respectively, about the fixed axes B and C. Let t and s be, respectively, the tangent and normal to the curves at the point of contact P. Denoting by a the frame of the machine, the fixed link to which the axes B and C are attached, it is evident that the centers of these axes are the centers of the motions of b and c, respectively, relative to the fixed link a. According to the "law of three centers," when three bodies move relative to one another, the three instantaneous centers must lie in a straight line.

Now, the center of the motion of b relative to the fixed link a, is the center of the axis B; likewise, the center of the motion of c relative to a is the center of the axis C; hence, the instantaneous center of the motion of b relative to c must lie on the line joining the centers of the axes B and C. But in the preceding paragraph we showed that the instantaneous center of the relative motion of b and c lies on the normal s; therefore, it lies at M, the intersection of the normal with the line joining the center of the axes B and C. In all such cases, *the instantaneous center of the relative motion of two bodies that are in direct contact and turn about fixed centers is the point in which the normal through the point of contact cuts the "line of centers."*

The location of the instantaneous center gives a ready means of determining the relative angular velocities of the bodies b and c about their axes B and C, respectively. See "Home Study Magazine," July, 1898, article entitled "Plane Motion." The instantaneous center M has the same velocity whether it is considered a point of b or a point of c.

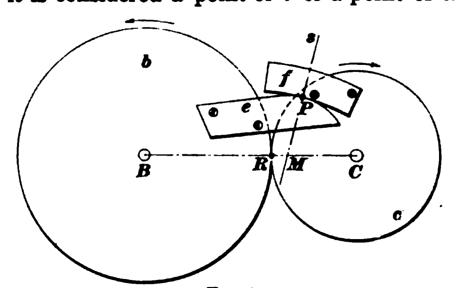

FIG. 3.

Denoting the angular velocities of b and c, respectively, by W_b and W_c, then the linear velocity of M is

$$W_b \times BM = W_c \times CM;$$

hence,
$$\frac{W_b}{W_c} = \frac{CM}{BM}.$$

In words, *the angular velocities of two bodies in contact and turning about fixed axes are inversely as the segments into which the common normal at the point of contact divides the line joining the axes.*

An important application of the principles just stated is found in the determination

of the proper forms of gear-teeth. Suppose we have a pair of circular disks b and c, Fig. 3, turning about the axes B and C, respectively, and in contact at the point R. Evidently, if the disks are pressed together and motion is given to b, the motion will be transmitted to c; furthermore, the relative motion of b and c will be pure rolling. Since the points in the circumferences have the same linear velocity, the angular velocities of the disks are inversely as the radii $B R$ and $C R$; for example, $B R = 3$, and $C R = 2$, then b will make two revolutions while C is making three. Circular disks of this kind may be, and often are, used for transmitting motion. However, all that prevents them from slipping is the friction between the surfaces in contact, and for large forces some means must be provided for making the motion positive. Suppose that on the disk b is screwed a projection e and on c a projection f, each having a curved outline. Then, when the disk b is turned, the curved outline of e will come in contact with the curved outline of f and the transmission of motion from b to c will be rendered positive beyond doubt. This is the procedure adopted in the case of gear-wheels. Projecting teeth on the circumference of the driver engage with similar teeth on the circumference of the driven wheel. For convenience, the teeth are symmetrical and have practically the same form in both wheels. However, in principle, the action of a pair of teeth is in every way similar to the action of the lugs e and f, Fig. 3. The curved outlines, Fig. 3, are in contact at the point P, and the line s is the common normal to the curves at the point P. Suppose this normal s cuts the line of centers $B C$ at the point M; then, from what has been stated previously, the angular velocities of b and c are inversely as the segments $B M$ and $C M$. But the angular velocities of the rolling disks are inversely as the segments $B R$ and $C R$. Hence, if the positive motion transmitted by the lugs e and f is to be exactly the same as the original rolling motion of the disks, it is evident that the point M must coincide with the point of contact R; that is, the common normal to the curves in contact must always pass through the point of contact of the circular disks. It is evident that if this condition is to be fulfilled, the curves we choose as the outlines of e and f cannot be selected at random.

Suppose we assume the circumferences of the disks b and c to be the pitch circles of a pair of gear-wheels, and the bounding curves of the lugs e and f to be the outlines of gear-teeth. Then it appears that the condition to be fulfilled by the tooth outlines in order that the transmission by means of the teeth shall be exactly equivalent to the rolling of the pitch circles is that *the common normal to the tooth outlines through their point of contact shall pass through the point of contact of the pitch circles.* The determination of tooth outlines that will satisfy this condition is an extremely interesting branch of the geometry of motion, but lies beyond the scope of this article.

We have shown that if the relative motion of two bodies is a pure rolling, the instantaneous center must be the point of contact. But as the instantaneous center must lie on the line of centers, it follows that the first condition of pure rolling is that the point of contact must always lie on the line of centers. If, as in Fig. 2, the point of contact is at some distance from the line of centers,

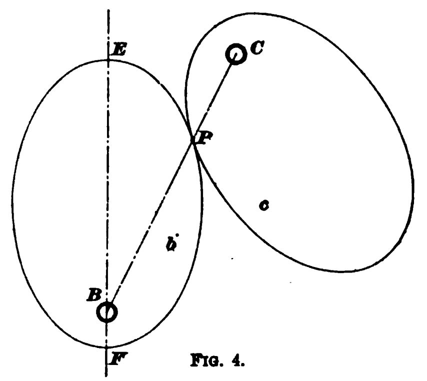

FIG. 4.

the motion must be partly or wholly sliding. Let us apply this statement to the case of a pair of gear-wheels. When two teeth first come in contact, the point of contact is at some distance from the line joining the axes, and there is, in consequence, a certain amount of sliding between the teeth. As the point of contact approaches the line of centers ($B C$, Fig. 3), the sliding becomes less; when the point lies on the line of centers, the sliding disappears, and the relative motion of the teeth at this instant is pure rolling. In view of this principle, the following statement from an advertising booklet on gears is, to say the least, surprising: "A properly formed tooth of the involute pattern does not have sliding friction, as claimed by its opponents."

In conclusion, non-circular disks, or wheels that fulfil the conditions of pure rolling, demand our attention. In the actual construction of machines the great majority of

gears—parts with rolling pitch circles—are circular, the angular velocity ratio being constant. In special machinery, however, it is frequently desirable to construct gears that will have a varying angular velocity ratio. The pitch lines of such gears are necessarily non-circular, but must fulfil the conditions of pure rolling. It is quite evident that the bounding curves of such non-circular wheels cannot be chosen at random if they are to fulfil these conditions. There are certain curves, however, whose properties are such that under certain circumstances they will roll and at the same time rotate about fixed axes. In the majority of cases non-circular wheels have one or more of these curves for their boundaries.

The simplest case of non-circular rolling wheels is furnished by two equal ellipses (Fig. 4). The first axis B must pass through one of the foci of the ellipse b; similarly, C must pass through a focus of c, and the distance $B\,C$ must be equal to the major axis $E\,F$ of the ellipse. Under these circumstances the point of contact P will always be on the line $B\,C$, and the relative motion of the ellipses will be pure rolling. Gears with elliptical pitch lines are sometimes used in shaping machines to give a quick-return motion to the ram.

Space will not permit more than a brief mention of other curves that may be used as outlines for rolling wheels. Two equal parabolas may be thus used with the limitation that one has a motion of translation while the other rotates about an axis through its focus. Two equal hyperbolas will also roll under certain circumstances.

THE REQUISITE STRENGTH OF LINTELS.

F. A. Kaiser.

TRANSVERSE STRENGTH OF BRICKWORK — THE LINTEL AS A RESTRAINED BEAM — COMMON METHODS OF COMPUTATION.

BRICK masonry is seldom employed where any stress other than direct compression will come on it, but it is sometimes subjected to transverse or bending stress also. Since the compressive strength of mortar is so great, compared to its tensile strength or to its adhesive power, it is evident that the ability of brickwork to resist bending stresses depends almost entirely on these two latter strengths, of which its adhesion, or power to stick to brick or stone, deserves the most attention, as giving the most conservative results. The ability of brickwork to act as a beam is seldom taken into account; but it is a fact that brickwork laid in good mortar has considerable transverse strength, and it is this strength that makes it possible for some buildings to stand up under the buffeting of the elements, even while presenting an appearance that led one engineer to say of a certain building that it stood up only "by the grace of God and the force of habit."

Very few experiments have been made on the adhesive strength of mortars. This strength depends to a large extent on the porosity of the bricks fastened together, and on the age of the mortar. The few records extant give about 30 pounds per square inch for 1-to-2 lime mortar, 6 months old, on common bricks; 18 pounds for hydraulic lime mortar, 7 days old; 18 pounds for lime mortar, 6 months old, on soft bricks; and 40 to 50 pounds for 1-to-2 Portland cement mortar, 40 days old, on common bricks.

The brickwork over an opening can be considered as a beam fixed at the ends and uniformly loaded, as illustrated in Fig. 1. The uniform load is the weight of the brickwork above. It will be seen that the bricks in the courses a, near the top, will be pressed together, thus bringing the mortar in the vertical joints in compression; while the bricks in the courses b, at the bottom, would tend to be pulled apart, depending on the adhesion of the mortar in the vertical joints of these courses for stability. By an analysis of the stresses in such a beam it can be proved that brickwork over an opening will be self-supporting when the height over the opening is equal to the square of the span in feet divided by twice the modulus of rupture, which may be taken equal to the safe adhesive power. This rule is of value chiefly in cutting holes through old brick walls. Let it be desired to cut a 15-foot opening in such a wall, and it is desired to know whether shoring is necessary. In such a case, the adhesive power can be determined by actual trial; and a value of 10 pounds per square inch should give a

large enough factor of safety for any good masonry. By the above rule,

$$H = \frac{15^2}{2 \times 10} = \frac{225}{20} = 11.25 \text{ feet.}$$

Hence, if the wall is solid at least 11 feet high above the opening, it will be self-supporting. If higher than 11 feet, it is

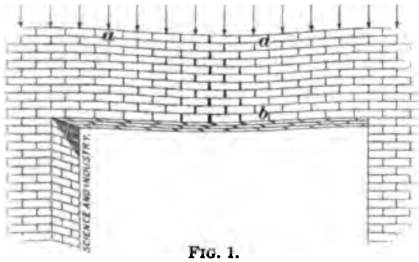

FIG. 1.

stronger than necessary; and if less than 11 feet, or if a floor or other weight depends on the wall for support, it will need shoring or needling.

We may also deduce the rule that, in building a new wall over a lintel, the greatest pressure coming on the lintel at any time is equal to one-half the entire weight of the brickwork over the opening. Knowing the strength of the lintel (a method for finding which will be explained later), we can tell how high we may safely build the wall above it. Thus, supposing that a girder of 10 feet span will hold safely 10 tons of uniformly distributed load, equivalent to the weight of a 1-foot wall 14 feet high, we may build the wall twice 14, or 28, feet high without further support, provided that the work is not carried on too rapidly, so as to allow the mortar to attain a small average strength. If the work is carried on very rapidly, the lintel must be braced up to prevent excessive deflection.

There are two methods in common use for estimating the pressure on a lintel due to a mass of masonry. One method consists in assuming the masonry to be a fluid, and taking the load on the lintel to be the weight of all the masonry above the opening. As a wall would be several days in building, and would acquire some strength, the weight on the girder cannot be compared to a fluid volume. The other method is to assume the pressure to be the weight of a triangular wedge of masonry, of which the base is equal to the span and the altitude equal to one-third the span. To avoid excessive deflection and cracking of the brickwork, if the lintel is proportioned in this way, it is well to brace it up temporarily, when the height of the wall approaches the dangerous point as computed in a former paragraph, until the brickwork has attained considerable strength.

Assuming the above method of finding the pressure on a lintel, we will now pass to the consideration of the lintel itself.

Lintels are made of wood, stone, or iron. The introduction of large timbers in masonry walls is not advisable, on account of the shrinkage, which will cause cracks. Some specifications require that wooden lintels must not extend into the brickwork more than 2 inches on either side of the opening. While this is advisable, to prevent damage from shrinkage, yet the same beam, if firmly built into the wall, would be 50 per cent. stronger and would deflect but one-fifth as much under the same load. Stone and iron beams, not being liable to shrinkage, may be so built in.

To illustrate the method used in applying the foregoing principles, let us assume a problem (see Fig. 2). An opening of 12 feet span is to be left in an 18-inch brick wall built with good lime mortar. The wall is to be supported by two yellow-pine beams 9 inches wide, laid side by side, and extending 2 inches into the brickwork on each side. How deep must the beams be?

The weight on the lintel will be that of a triangular mass of brickwork 12 feet long, 4 feet high, and 1½ feet thick, having a volume of 36 cubic feet. If the brickwork weighs about 140 pounds per cubic foot,

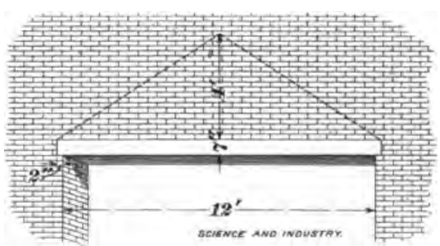

FIG. 2.

the weight on the lintel will be $140 \times 36 = 5{,}040$ pounds.

The size of beam necessary may be computed from the formula

$$\frac{WL}{6} = KS,$$

where W = weight (5,040 pounds);
L = span, in inches;
K = section modulus of the beam;
S = safe fiber stress (about 1,000 pounds per square inch for timber).

Then, $\frac{5{,}040 \times 12 \times 12}{6} = K \times 1{,}000.$

Solving, we get $K = 121$.

Now, for a beam of rectangular cross-section,

$$K = \frac{bd^2}{6},$$

where b = width, 18 inches (considering the two beams as acting together);

and d = the necessary depth.

Then, $121 = \frac{18d^2}{6}$; or, d = say, 7 inches.

The height of the lintel, especially if built into the wall, should be made equal to some number of courses plus the thickness of mortar joints at top and bottom, so that the brick will rest directly on the lintel without an intervening mortar joint. With ordinary brickwork this would necessitate the use of a beam about $8\frac{1}{4}$ inches deep. To find how much the two 8-inch beams will hold, first compute the section modulus from the formula

$$K = \tfrac{1}{6}bd^2 = \tfrac{1}{6} \times 18 \times 8^2 = 192.$$

Substituting in the formula

$$W = \frac{6KS}{L},$$

we have, as the safe strength of the lintel,

$$W = \frac{6 \times 192 \times 1{,}000}{12 \times 12} = 8{,}000 \text{ pounds}.$$

This is equal to the entire weight of the wall when about 3 feet high. According to the principle stated in the first part of this article, we should brace up the lintel when the wall approaches a height of 6 feet above the opening.

If a stone lintel were to be used in this place, we would assume a safe fiber stress of about 150 pounds per square inch, allowing a factor of safety of 10. We should then find that a lintel about 16 inches deep would be necessary.

If we wish to use two steel channels to support the wall, we use a safe fiber stress of 15,000 pounds per square inch, fifteen times as great as that used for wood, and therefore get a section modulus equal to one-fifteenth that of the wooden beam, or 8. By referring to one of the manufacturers' catalogues, we find that two 6-inch channels each weighing 8 pounds per foot will be strong enough.

As the stone and the iron beams could be built into the wall, the above sizes would give ample factors of safety, and would not need extra support during the building of the wall.

ARCHITECTURAL CONVENTION.

THE MOTTO of the first National Convention of Architectural Societies, held at Cleveland recently, was "Progress Before Precedent"—a most significant one, predicting a great amount of scientific advancement in architectural practice. It is not necessary for *progress* that *precedent* be ignored, but a healthy painstaking analysis of the fundamental principles governing the production of the precedent will tend towards creative design more adapted to the modern "fitness of things" than much of that now passing for up-to-date work.

Mr. Julius F. Harder, of New York, said: "There is a sentiment which seeks to depart from architectural isolation and desires us to rub elbows with our fellows in the allied arts. There is a feeling that our architectural organization should be expanded to a degree of inclusiveness comprising all the allied arts—sculpture and painting, workers in decorative glass, metal, mosaics, and every form of artistic workmanship and product which enters into the fine art of building beautifully, and the idea of expansion even extends to including reenforcement by the admission of lay members in clubs to certain restricted membership.

"There is a strong current perceptible, setting in the direction of establishing the practice of architecture as a business upon an appropriate pedestal of respectability and responsibility; to begin the work of establishing professional ethics and providing the organization for control and discipline; to rescue our practice from the slough of despondency in which it is freely admitted to find itself; and to make a line of demarcation between those methods which are considered as proper and productive of wholesome results and those others which are generally agreed to be improper and invariably produce bad results.

"This convention appears to be unanimously of the opinion that architectural organizations should assert themselves in their own community and municipality, and also nationally, to fulfil their obligations to society, to the end of securing proper consideration from an architectural point of view for public works of art and architecture of all classes."

THE SELECTION OF A BOILER.

W. H. Wakeman.

POINTS TO BE CONSIDERED—ANY KIND NOT SUITABLE FOR EVERY PLACE—WHY GOOD BOILERS ARE SOMETIMES DISCARDED BEFORE THEY ARE WORN OUT—SOME ADVICE.

ARTICLES have appeared at different times in various publications on the above subject, but nearly all of them treat only of the determination of the capacity of boilers to evaporate water, after stating the weight of steam that is required per hour. Such articles are valuable as far as they go, but it appears to me as if there was something to be said concerning the particular type of boiler to be adopted for a given place and known conditions that will prove of interest to those that contemplate the erection of a new plant or the reconstruction of an old one. All authorities agree that a boiler should have constant attention while a brisk fire is burning under it, and they also know that this attention is not always given; consequently, when it is known in advance that the fireman will have to attend to other duties, the decision concerning the kind of boiler to be installed should be affected by this consideration.

A boiler that consists of pipes connected together in one way or another may be an economical steam generator, and can be built to stand a higher pressure than another type composed of one or more large parts. However, the pipe boiler will hold but little water; hence, the feed must be steady, or there is danger of ruining the whole structure in short order.

Here it may be mentioned that every boiler should be fed constantly, this being conducive to both safety and economy; but many things are not always done as they should be, and this is one of them. Consider that a pump or an injector may be left doing its work nicely, and yet two minutes afterwards the former may stop, or the latter "kick," the result being that no water goes into the boiler. In such a case, before the fireman is aware of it, much damage may result. A certain steam user, who was erecting a new plant, stated to the writer that he intended to allow the engineer 60 per cent. of his time for caring for the engine and boiler, but the remaining 40 per cent. must be spent in doing other work about the place. Under such a condition, a boiler that will hold water enough to prevent rapid fluctuations of the water-line should be adopted; but, as the kind of boiler that the party mentioned has purchased will only hold a few barrels, it seems to me that a great mistake has been made.

The fact that a boiler holds but little water does not in itself make it an economical steam generator, for, while steam may be raised in it in a few minutes, there is no reservoir for heated water or for steam. Hence, as soon as the fire burns low, the pressure falls, and after the fire is banked at night the whole boiler cools off in short order; consequently, much or all of the coal saved during one day is used in getting up steam the next morning. On the other hand, a boiler that has a large reservoir for hot water will hold the heat so steadily that there will be almost as much pressure in the morning as there was the night before; therefore, I believe that there is little or no difference in the economy of the two types when a whole week's run is taken into consideration. This is not a theoretical assumption, but has been demonstrated to be a practical fact, where both kinds were side by side in the same boiler room.

The next point that I shall mention is worthy of serious consideration when contemplating the purchase of a boiler, and is well illustrated by the following incident. One day when passing an establishment where hundreds of tons of coal are burned each year, I saw a large boiler that had been discarded. It was not half worn out, but there it lay—for sale at a low price if anybody cared to invest surplus cash. Why this apparent waste of capital? The boiler was of a well-known vertical type, hundreds of which are in successful operation throughout the country—then why was this one thrown away? The explanation is as follows: The feedwater that must be used at the establishment forms a hard scale. Furthermore, the boilers are run night and day, so that opportunities for cleaning them are not as plentiful as they might be. Moreover, owing to the difficulty of cleaning this type of boiler in the limited time allowed, scale piled up on the crown sheet, keeping

the water from coming in contact with the iron, and making it necessary to shut down and expand the old tubes and put in new ones frequently, until the interruption due to repairs could be tolerated no longer—then the boiler was thrown out. The engineer who selected that steam generator knew what kind of water he had to use in it just as well before it was purchased as he does today, and yet he allowed an improper type to be bought!

The lesson to be learned from this is that, where impure water must be used, the boilers adopted must be so designed that they can be cleaned readily. The plant just referred to is so situated that the boiler room is small and it cannot be made larger without great expense; hence, another kind of vertical boiler was installed, but whether it will be satisfactory or not remains to be seen.

The one just put in can be thoroughly examined, so that it is proper to assume it can be cleaned. These are points in its favor, and should be carefully considered; yet, in another plant with which I am familiar, that same kind of a vertical boiler has been thrown out, and a horizontal tubular boiler put in its place. The reason given for this action is that it could not be kept clean. This seems to indicate a bad prospect for the man that has just put one of them into service, and also shows that opinions on the same subject may differ.

Very great stress is always laid on the fact that a vertical boiler occupies less floor space than a horizontal one, but there are many cases where this is not worthy of consideration. I have just read of the sale of a small piece of land in New York City, the price of which was at the rate of more than $13,000,000 per acre. Where real estate is that valuable, it pays to economize floor space, but the next plant I shall mention is located outside of city limits, where land enough for a large boiler plant could be bought for $500, and yet vertical boilers were installed.

There is no objection to the selection of this type of boiler so far as I know, provided it proves satisfactory to the parties that must pay the coal bills and do the work necessary to its successful operation. But in this particular instance it seems that vertical boilers were not a success, for horizontal water-tube boilers have since been erected in that plant.

I have selected for illustration cases where boilers have been thrown out as worthless, because I desire to show that the points mentioned are not the mere fanciful ideas of an enthusiast, but substantial objections.

If it is decided that horizontal water-tube boilers are the best, it should not be taken for granted that all of these are equally safe and efficient. It must be remembered that there are many different kinds of this type, and some of them have not been tested by years of "rough-and-tumble" service. A certain boiler of this kind was installed before a severe hydraulic test had been applied to ascertain its safety under a high pressure; when this test was applied, the boiler showed defective design. It became necessary to remove nearly all of the brick setting, and greatly strengthen the weak parts before a boiler-insurance company would accept it. This shows that we cannot be too careful about accepting untried apparatus. The engineer that selected this boiler considered that he was getting a safe boiler, because a number of them were in use in other plants, and no complaint had been made about them. But one very important point had been entirely overlooked: all of those in satisfactory use were operated under comparatively low pressure. When one of them was tested for a high pressure, as told above, it failed ignominiously. I think that the point will be plain without further explanation.

It is claimed that water-tube boilers will not explode, but the man that purchases one of them and places it in charge of an ignorant and careless fireman, runs the risk of having his dream of security rudely disturbed. I have just been looking at the engraving of a tube about 4 inches in diameter that became overheated and burst. The accompanying text informs me that its failure caused but little delay, and $15 paid the bill. A short time ago I examined a section of a 4-inch tube that had burst and caused damage to the amount of $5,000, so that the exception to any general rule is again in evidence.

There is one point in favor of purchasing internally fired boilers, either horizontal or vertical. With these it is possible to make the shell of plates thick enough to withstand any reasonable required pressure, without encountering the serious objection of externally fired boilers being so thick for very high pressures that heat will not readily pass through them.

I have already referred to the fact that vertical boilers are difficult to clean, but this is partially due to an excessive number

of tubes making it impossible to reach all parts of the lower tube-sheet, and also to a lack of handholes in proper places. Fortunately, these objections can be overcome, but on general principles I believe that it is better to have a boiler made right in the shop than to wait until it has been used a year or two, and partially ruined, and then have the necessary changes made.

There is at least one defect that is found in both vertical and horizontal internally fired boilers. Below the level of the grates there are places where the water stands all day without circulation, and in some cases without getting warm enough to burn the hand. Consequently, mud and scale collect at these points, corrosion gets in its work, the plates and staybolts are weakened, and the whole structure is endangered. The accumulation of scale and mud may be partially overcome in vertical boilers by laying a chain in the lower part of the water leg. Whenever the boiler is washed out, this chain is drawn back and forth so as to loosen up the sediment, thus making it possible to wash it out.

In horizontal internally fired boilers, it is even more difficult to keep the water leg, below the grates, in good condition. In some places where these matters are watched carefully, a pump of some kind is employed to take water out of the leg and discharge it into the upper part of the water space, in order to maintain proper circulation.

A few weeks ago I received a letter from a gentleman in one of our Southern states, telling me that he was thinking of putting in a rather complicated type of water-tube boiler to furnish steam for his saw and planing mill, asking my advice on the subject, and intimating that my opinion would have some weight. I could not claim to be familiar with all of the conditions, but visions of huge piles of shavings, sawdust, and slabs that accumulated after enough had been used to make all the steam wanted, rose before me, indicating that economy of fuel was not a factor in the case. I am quite sure that the boiler in this place, without regard to when it was needed, would be cleaned only when they had time for it; in short, that the usual sawmill practice would prevail.

For such service, good two-flue boilers are all that is required, for they will make steam if enough fuel is used. When cleaning-up time comes, every part may be reached with the pick and scraper, little effort being required to clean them enough to prevent the plates from being burned. Where a plant is to receive good care and there is abundance of room, the horizontal water-tube boiler of approved design answers very well, and I believe that there is no good reason why the common tubular boiler should not be used, under the same conditions.

If floor space is very valuable, a special form of water-tube boiler that is short and high may be used. Or, a vertical boiler that is not literally filled with tubes, and has handholes enough to allow it to be thoroughly cleaned, may be installed, according to the choice of the engineer.

A review of this article may cause some reader to conclude that there are objections to every kind of boiler. So there are, when a boiler is installed that is not suitable for the location and the conditions. But, by using judgment, a boiler adapted for almost any given location and given set of conditions may be chosen. If the selection is made haphazard, there are many chances for trouble, expense, and dissatisfaction. I have called attention to some of the points that lead to trouble, etc., so that the reader, having had due warning, may profit by the unpleasant experiences of others and escape their fate.

ELECTRICAL MACHINERY IN MINES.

A PAPER recently read before The Institution of Mining Engineers of London, by Herr Heise and Dr. Theim, gives the results of a valuable and extensive series of experiments on the ignition of firedamp and coal dust by electricity. The series of experiments was undertaken to determine whether electrical machinery may be a source of danger in fiery or dusty mines. From the experiments it appears that, under certain conditions, a very small amount of electrical energy is sufficient to ignite firedamp; under all circumstances, visible sparks are to be regarded as dangerous. With the classes of coal dust that were experimented on, it was found impossible to cause an explosion of coal dust alone by electricity.

ELECTRICAL STANDARDIZATION.*

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The tests should be made with a sine wave of E. M. F., or, where this is not available, at a voltage giving the same striking distance between needle points in air as a sine wave of the specified E. M. F., except where expressly specified otherwise. As needles, new sewing needles should be used. It is recommended to shunt the apparatus during the test by a spark gap of needle points set for a voltage exceeding the required voltage by 10 per cent. A table of approximate sparking distances is given in Appendix V.

38. The following voltages are recommended for apparatus not including transmission lines or switchboards:

Rated Terminal Voltage.	Capacity.	Testing Voltage.
Not exceeding 400 volts	Under 10 K. W.	1,000 volts.
Not exceeding 400 volts	10 K. W. and over	1,500 volts.
400 and over, but less than 800 volts	Under 10 K. W.	1,500 volts.
400 and over, but less than 800 volts	10 K. W. and over	2,000 volts.
800 and over, but less than 1,200 volts	Any	3,500 volts.
1,200 and over, but less than 2,500 volts	Any	5,000 volts.
2,500 and over	Any	Double the normal rated voltages.
Synchronous motor fields and fields of converters started from the alternating-current side		5,000 volts.

Alternator field circuits should be tested under a breakdown test voltage corresponding to the rated voltage of the exciter, and referred to an output equal to the output of the alternator; i. e., the exciter should be rated for this test as having an output equal to that of the machine it excites.

Condensers should be tested at twice their rated voltage and at their rated frequency.

The values in the table above are effective values, or square roots of mean squares, reduced to a sine wave of E. M. F.

39. In testing insulation between different electric circuits, as between the primary and the secondary transformers, the testing voltage must be chosen corresponding to the high-voltage circuit.

40. In transformers of from 10,000 to 20,000 volts, it should be considered as sufficient to operate the transformer at twice its rated voltage, by connecting first the one and then the other terminal of the high-voltage winding to the core and to the low-voltage winding. The test of dielectric resistance between the low-voltage winding and the core should be in accordance with the recommendation in Section 38, for similar voltages and capacities.

41. When machines or apparatus are to be operated in series, so as to employ the sum of their separate electromotive forces, the voltage should be referred to this sum, except where the frames of the machines are separately insulated both from ground and from each other.

REGULATION.

42. The term regulation should have the same meaning as the term "inherent regulation," at present frequently used.

43. The regulation of an apparatus intended for the generation of constant potential, constant current, constant speed, etc. is to be measured by the maximum variation of potential, current, speed, etc. occurring within the range from full load to no load, under such constant conditions of operation as give the required full-load values, the condition of full load being considered in all cases as the normal condition of operation.

44. The regulation of an apparatus intended for the generation of a potential, current, speed, etc. varying in a definite manner between full load and no load, is to be measured by the maximum variation of potential current, speed, etc. from the satisfied condition, under such constant conditions of operation as give the required full-load values.

If the manner in which the variation in potential, current, speed, etc. between full load and no load is not specified, it should be assumed to be a simple linear relation; i. e., undergoing uniform variation between full load and no load.

The regulation of an apparatus may, therefore, differ according to its qualification for

*Concluded from the November, 1899, number.

use. Thus, the regulation of a compound-wound generator specified as a constant-potential generator will be different from that which it possesses when specified as an over-compounded generator.

45. The regulation is given in percentage of the full-load value of potential, current, speed, etc., and the apparatus should be steadily operated during the test under the same conditions as at full load.

46. The regulation of generators is to be determined at constant speed; of alternating apparatus, at constant impressed frequency.

47. The regulation of a generator unit, consisting of a generator united with a prime mover, should be determined at constant conditions of the prime mover; i. e., constant steam pressure, head, etc. It would include the inherent speed variations of the prime mover. For this reason the regulation of a generator unit is to be distinguished from the regulation of either the prime mover or of the generator contained in it, when taken separately.

48. In apparatus generating, transforming, or transmitting alternating currents, regulation should be understood to refer to non-inductive load; that is, to a load in which the current is in phase with the E. M. F. at the output side of the apparatus, except where expressly specified otherwise.

49. In alternating apparatus receiving electric power, regulation should refer to a sine wave of E. M. F., except where expressly specified otherwise.

50. In commutating machines, rectifying machines, and synchronous machines, as direct-current generators and motors, alternating-current and polyphase generators, the regulation is to be determined under the following conditions:

(*a*) At constant excitation in separately excited fields; (*b*) with constant resistance in shunt-field circuits; and (*c*) with constant-resistance shunting series-fields; i. e., the field adjustment should remain constant, and should be so chosen as to give the required full-load voltage at full-load current.

51. In constant-potential machines, the regulation is the ratio of the maximum difference of terminal voltage from the rated full-load value (occurring within the range from full load to open circuit) to the full-load terminal voltage.

52. In constant-current machines, the regulation is the ratio of the maximum difference of current from the rated full-load value (occurring within the range from full load to short circuit) to the full-load current.

53. In constant-power machines, the regulation is the ratio of maximum difference of power from the rated full-load value (occurring within the range of operation specified) to the rated power.

54. In over-compounded machines, the regulation is the ratio of the maximum difference in voltage from a straight line connecting the no-load and full-load values of terminal voltage as function of the current, to the full-load terminal voltage.

55. In constant-speed continuous-current motors, the regulation is the ratio of the maximum variation of speed from its full-load value (occurring within the range from full load to no load) to the full-load speed.

56. In transformers, the regulation is the ratio of the rise of secondary terminal voltage from full load to no load (at constant primary impressed terminal voltage), to the secondary terminal voltage.

57. In induction motors, the regulation is the ratio of the rise of speed from full load to no load (at constant impressed voltage), to the full-load speed. The regulation of an induction motor is, therefore, not identical with the slip of the motor, which is the ratio of the drop in speed from synchronism to the synchronous speed.

58. In converters, dynamotors, motor generators, and frequency changers, the regulation is the ratio of the maximum difference of terminal voltage at the output side from the rated full-load voltage (at constant impressed voltage and at constant frequency), to the full-load voltage on the output side.

59. In transmission lines, feeders, etc., the regulation is the ratio of maximum voltage difference at the receiving end, between no load and full non-inductive load, to the full-load voltage at the receiving end, with constant voltage impressed upon the sending end.

60. In steam engines, the regulation is the ratio of the maximum variation of speed in passing from full load to no load (at constant steam pressure at the throttle), to the full-load speed.

61. In a turbine or other water motor, the regulation is the ratio of the maximum variation of speed from full load to no load (at constant head of water; i. e., at constant difference of level between tail-race and head-race), to the full-load speed.

62. *Variation and Pulsation.*— In prime

movers that do not give an absolutely uniform rate of rotation or speed, as in steam engines, the "variation" is the maximum angular displacement in position of the revolving member expressed in degrees, from the position it would occupy with uniform rotation, and with one revolution as 360°; and the pulsation is the ratio of the maximum change of speed in an engine cycle to the average speed.

63. In alternators or alternating-current circuits in general, the variation is the maximum difference in phase of the generated wave of E. M. F. from a wave of absolutely constant frequency, expressed in degrees, and is due to the variation of the prime mover. The pulsation is the ratio of the maximum change of frequency during an engine cycle to the average frequency.

64. If n = number of poles, the variation of an alternator is $\frac{n}{2}$ times the variation of its prime mover if direct-connected, and $\frac{n}{2}p$ times the variation of the prime mover, if rigidly connected thereto in the velocity ratio p.

65. The pulsation of an alternating-current circuit is the same as the pulsation of the prime mover of its alternator.

RATING.

66. Both electrical and mechanical power should be expressed in kilowatts, except when otherwise specified. Alternating-current apparatus should be rated in kilowatts on the basis of non-inductive condition; i. e., with the current in phase with the terminal voltage.

67. Thus the electric power generated by an alternating-current apparatus equals its rating only at non-inductive load; that is, when the current is in phase with the terminal voltage.

68. Apparent power should be expressed in kilovolt-amperes as distinguished from real power in kilowatts.

69. If a power factor other than 100 per cent. is specified, the rating should be expressed in kilovolt-amperes and power factor, at full load.

70. The full-load current of an electric generator is that current which with the rated full-load terminal voltage gives the rated kilowatts, but in alternating-current apparatus only at non-inductive load.

71. Thus, in machines in which the full-load voltage differs from the no-load voltage, the full-load current should refer to the former.

If P = rating of an electric generator;
E = full-load terminal voltage,
then, in a continuous-current machine or single-phase alternator, the full-load current is

$$I = \frac{P}{E};$$

in a three-phase alternator,

$$I = \frac{P}{E\sqrt{3}};$$

and in a quarter-phase alternator,

$$I = \frac{P}{2E}.$$

72. Constant-current machines, such as series arc-light generators, should be rated in kilowatts based on terminal volts and amperes at full load.

73. The rating of a fuse or circuit breaker should be the current strength at which it will open the circuit, and not the working-current strength

74. *Classification of Voltages and Frequencies.* In direct-current, low-tension generators, the following average terminal voltages are in general use and are recommended: 125 volts, 250 volts, 550 volts.

75. In direct-current and alternating-current low-pressure circuits, the following average terminal voltages are in general use and are recommended: 110 volts, 220 volts. In direct-current power circuits, for railway and other service, 500 volts may be considered as standard.

76. In alternating-current high-pressure circuits at the receiving end, the following pressures are in general use and are recommended: 1,000 volts, 2,000 volts, 3,000 volts, 6,000 volts, 10,000 volts, 15,000 volts, 20,000 volts.

77. In alternating-current high-pressure generators, or generating systems, the following terminal voltages are in general use and are recommended: 1,150 volts, 2,300 volts, 3,450 volts. These pressures allow of a maximum drop in transmission of 15 per cent. of the pressure at the receiving end. If the drop required is greater than 15 per cent., the generator should be considered as special.

78. In alternating-current circuits, the following approximate frequencies are recommended as desirable: 25 ∿ or 30 ∿, 40 ∿, 60 ∿, 120 ∿.* These frequencies are already in extensive use and it is deemed advisable to adhere to them as closely as possible.

*The frequency of 120 ∿ may be considered as covering the already existing commercial frequencies between 120 ∿ and 140 ∿, and the frequency of 60 ∿ as covering the already existing commercial frequencies between 60 ∿ and 70 ∿.

79. *Overload Capacities.*—All guarantees on heating, regulation, sparking, etc. should apply to the rated load, except where expressly specified otherwise, and in alternating-current apparatus to the current in phase with the terminal E. M. F., except where a phase displacement is inherent in the apparatus.

80. All apparatus should be able to carry a reasonable overload without self-destruction by heating, sparking, mechanical weakness, etc., and with an increase of temperature elevation not exceeding 15° C. above those specified for full loads. See Sections 25 to 31.

81. Overload guarantees should refer to normal conditions of operation regarding speed, frequency, voltage, etc., and to non-inductive conditions in alternating apparatus, except where a phase displacement is inherent in the apparatus.

82. The following overload capacities are recommended:

1. In direct-current generators and alternating-current generators, 25 per cent. for ½ hour.

2. In direct-current motors and synchronous motors, 25 per cent. for ½ hour, 50 per cent. for 1 minute, except in railway motors and other apparatus intended for intermittent service.

3. Induction motors, 25 per cent. for ½ hour, 50 per cent. for 1 minute.

4. Synchronous converters, 50 per cent. for ½ hour.

5. Transformers, 25 per cent. for ½ hour; except in transformers connected to apparatus for which a different overload is guaranteed, in which case the same guarantees shall apply for the transformers as for the apparatus connected thereto.

6. Exciters of alternators and other synchronous machines, 10 per cent. more overload than is required for the excitation of the synchronous machine at its guaranteed overload, and for the same period of time.

Appendix I.

EFFICIENCY.

Efficiency of Phase-Displacing Apparatus. In apparatus producing phase displacement, as, for example, synchronous compensators, exciters of induction generators, reactive coils, condensers, polarization cells, etc., the efficiency should be understood to be the ratio of the volt-ampere activity to the volt-ampere activity plus power loss.

The efficiency may be calculated by determining the losses individually, adding to them the volt-ampere activity, and then dividing the volt-ampere activity by the sum.

1. In synchronous compensators and exciters of induction generators, the determination of losses is the same as in other synchronous machines under Sections 10 and 11.

2. In reactive coils, the losses are molecular friction, eddy losses, and I^2r loss. They should be measured by wattmeter. The efficiency of reactive coils should be determined with a sine wave of impressed E. M. F., except where expressly specified otherwise.

3. In condensers, the losses are due to dielectric hysteresis and leakage, and should be determined by wattmeter with a sine wave of E. M. F.

4. In polarization cells, the losses are those due to electric resistivity and a loss in the electrolyte of the nature of chemical hysteresis and are usually very considerable. They depend on the frequency, voltage, and temperature, and should be determined with a sine wave of impressed E. M. F., except where expressly specified otherwise.

Appendix II.

Apparent Efficiency.—In apparatus in which a phase displacement is inherent to their operation, apparent efficiency should be understood as the ratio of net power output to volt-ampere input.

Such apparatus comprise induction motors, reactive synchronous converters, synchronous converters controlling the voltage of an alternating-current system, self-exciting synchronous motors, potential regulators, and open magnetic circuit transformers, etc.

Since the apparent efficiency of apparatus generating electric power depends on the power factor of the load, the apparent efficiency, unless otherwise specified, should be referred to a load power factor of unity.

Appendix III.

Power Factor and Inductance Factor.—The power factor in alternating circuits or apparatus may be defined as the ratio of the electric power, in watts, to volt-amperes.

The inductance factor is to be considered as the ratio of wattless volt-amperes to total volt-amperes.

Thus, if p = power factor and q = inductance factor, then

$$p^2 + q^2 = 1.$$

The power factor =

$$\frac{\text{energy component of current or E. M. F.}}{\text{total current or E. M. F.}},$$

and the inductance factor =

$$\frac{\text{wattless component of current or E. M. F.}}{\text{total current or E. M. F.}}$$

$$= \frac{\text{true power}}{\text{volt-amperes}}.$$

Since the power factor of apparatus supplying electric power depends upon the power factor of the load, the power factor of the load should be considered as unity, unless otherwise specified.

Appendix IV.

The following notation is recommended:

E, e, voltage, E. M. F., potential difference.
I, i, current.
P, power.
Φ, magnetic flux.
B, magnetic density.
R, r, resistance.
X, x, reactance.
Z, z, impedance.
L, l, inductance.
C, c, capacity.

Vector quantities when used should be denoted by capital italics.

Appendix V.

The following is a table of sparking distances in air between opposed sharp needle points, for various effective sinusoidal voltages, in inches and in centimeters:

Kilovolts: Square Root of Mean Square.	Distance.	
	Inches.	Centimeters.
5	0.225	0.57
10	0.47	1.19
15	0.725	1.84
20	1.0	2.54
25	1.3	3.3
30	1.625	4.1
35	2.0	5.1
40	2.45	6.2
45	2.95	7.5
50	3.55	9.0
60	4.65	11.8
70	5.85	14.9
80	7.1	18.0
90	8.35	21.2
100	9.6	24.4
110	10.75	27.3
120	11.85	30.1
130	12.95	32.9
140	13.95	35.4
150	15.0	38.1

A GOOD TIN ROOF.

A. P. F.

THERE is a great hue and cry these days against the short-lived tin roof, and if architects, builders, and tinners do not see to it, the tin roof will soon be a thing of the past. The tendency of the times appears to be "lots of expensive style inside and a cheap roof to cover it." There was a time when we could get real good and durable tin roofs, but it seems difficult to secure one now. This may be due to keen competition, or it may be due simply to a lack of interest shown by architects and builders.

A tin roof is not as good as a copper one, but a good tin roof is certainly worth the money spent on it. In order to obtain a good tin roof it is advisable that the architect and builder should know what constitutes such a roof. For their special benefit we present the following facts, which we hope will be of value to our readers:

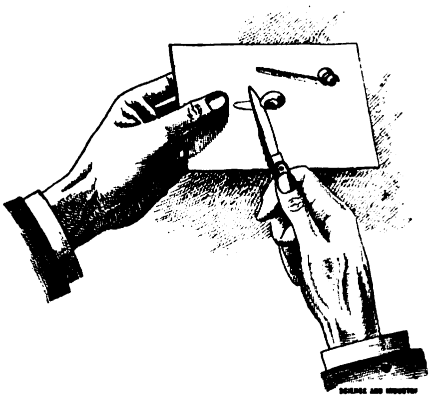
Manufacture of Tin Plates.—These plates, although we call them *tin* plates, are really *steel* plates, for they are made of steel and are only coated with tin, or, perhaps, with a mixture of lead and tin, to preserve them. When the plates are coated with tin alone, they are known as *tin* plates, and when coated with a mixture of lead and tin are known as *terne*.

The original method of manufacture was to dip the plates into the melted covering material, allowing the sheets to take on all the coating that was possible. Many of the best grades of roofing are made by this process today. Another process is known as the "patent roller process," by which the plates are put into a bath of molten covering material and then passed through between iron rolls. The pressure on the rolls leaves on the plates a thickness of coating that is determined by the distance the rolls are apart, and the thickness of the sheet steel. The rolls can be adjusted to squeeze off nearly all the coating, or to leave it on, just as the manufacturer sees fit, and just as the trade will accept or reject the material. If architects would try the thickness of the tin coating before allowing tin to be laid on the roofs, and condemn all thin-coated and otherwise imperfect material, manufacturers would keep their rolls a little farther apart in the future than they have been doing in the past. It would be an excellent lesson for many of the cheap tin manufacturers if the greater part of their goods were shipped back labeled: *found wanting and rejected.*

The thickness of the coating determines the value of roofing plates, for it is the

protection of the easily corroded steel that underlies it. When the protecting coating is worn off the steel plate, and the weather acts on the steel, holes become rusted through the roofing in a few months. In like manner, vapors in contact with the inside of a tin roof soon work their way through a skinny surface of lead and tin, and thus corrode the roof from the inside. Many a roof is "pin-holed" from the under side and appears in perfect condition on the outside, because of the red paint that protects it; but the pin holes are there just the same, and they are growing larger all the time.

Some technical books tell us that the best way to test roofing tin is to double it over, then with a hammer flatten it to a certain radius. Next bend it backwards and forwards until the plate breaks, and examine the fracture. Then pass judgment on the quality of the roof covering by the tenacity of the steel. This is all nonsense, and any sensible man knows it, for the tenacity, malleability, or ductility of the steel has very little to do with the durability of a tin roof.



The protective coating alone is the factor that determines its life. Scientific tests of tin are not required. All that the architect and builder has to do is to take his knife, run it over the surface, and peel off the covering, as shown in the figure. If he is not blind he will be able to see the thickness of the metal. Just try that experiment yourself. Go into the nearest tin shop, ask for two pieces of scrap tin—one a sample of the very cheapest in the shop, and the other a sample of the most expensive—scrape them and judge for yourself the difference between the quality and thickness of the two coatings. It is very important that the thickness of the coating should be tested before the tin is allowed to go on a roof, for the tightness and durability of the roof covering are just as important as the doors and windows of a house.

Brands.—There are different brands of roofing plates in the market at present. Some are "double-coated," some "redipped," others "double-dipped," etc.; but these terms are somewhat misleading. If, however, redipped means dipping a second time, and does not really say whether the second dip is made in melted tin, or tallow, then redipping or double-dipping are correct expressions. And if double-coated means one coat of tin and one coat of oil on top of that, then this expression is also correct. It is claimed that it is impossible for any plate to take on more metal than adheres to it by one dipping, and that no plate can have its coating increased in thickness by being redipped. This is claimed by good authority, and if it is so, wherein lies the value of these catchy expressions?

We have said that the durability of the roof depends on the protecting coating only, and this is correct if the steel underneath is perfect; but sometimes it happens that steel plates are not perfect, and then the durability of the roof depends, to a great extent, on the imperfections in the steel. To avoid trouble from this source of danger, the very best manufacturers in the country have an assorting department, where the defective sheets are picked out and separated from the good ones. There are, of course, in the manufacture of roofing plates, imperfect sheets, such as sheets with blisters, broken corners, cracks, and other flaws. All these sheets are called "wasters." These are packed by themselves, the boxes containing IC sheets being marked "ICW," and those containing IX sheets, "IXW." Wasters are always sold at prices considerably lower than the "primes," or perfect sheets, of the same brand, and it behooves all people that pay for tin roofs to look out for the wasters if they want to get a good job.

Sizes of Sheets.—There are two regular sizes of roofing plates, namely, 20 in. × 28 in. and 14 in. × 20 in. The large size is generally used on common work, from the fact that it requires fewer seams on the roof, and, consequently, cheapens the cost of laying. A third size, namely, 10 in. × 20 in., is also supplied, and is used generally for gutters and leader pipes.

Thickness.—There are two thicknesses of roofing plates that are commonly recognized. One is IC, which is No. 29 gauge and weighs 9 ounces to the square foot; and the other is IX, or No. 27 gauge, which weighs 10 ounces to the square foot. Sometimes a still heavier plate is called for, and it is therefore kept in stock by the best manufacturers. This plate is known as IXX, or No. 26 gauge, which is used for specially heavy work.

Weights.—The net weight per box of IC 14″ × 20″ roofing tin used to be 112 pounds, or 1 pound per sheet, making 112 sheets to the box. This was the old standard, but now it is reduced, by competition, and the desire for cheapness, to 108 pounds, which today is the standard net weight per box. It is rumored, however, and by good authority, too, that some plates are being sold that weigh very little more than 90 pounds per box. To architects, builders, and roofers again we say, "look out if you want a good job."

The old standard for IX plates used to be 140 pounds, net, per box, but very few brands, we are sorry to say, now weigh more than 135 pounds per box. The most reliable manufacturers guarantee the weights for the different boxes, and if the boxes do not come up to the guaranteed weight, then they can be shipped back. These manufacturers will make good the loss, if any, but manufacturers who guarantee the weights of the boxes do not require to have them sent back, for they are usually as good as their guarantee—that is, they give full weight.

There has been so much cheap tin sold under false names, or used on jobs by tinners on the "just-as-good" system, that reputable manufacturers decided to stamp their products, and now architects and builders will find that the best sheets on the market today are stamped with the mark of the brand, and with the designation of the thickness IC or IX. In fact, as a further protection, every box put out by certain manufacturers contains slips bearing the guarantee and the name of the assorter. Of course, this does not mean that a stamped roofing plate is necessarily a good one—oh no, for it is as simple a matter to stamp defective plates as perfect plates. But the stamp, together with the reputation of the manufacturer making the guarantee, tells the tale.

When first-class manufacturers come forward with this voluntary system of protecting property owners and architects, as described above, it is only fair that the latter should give the matter some consideration, and be careful to specify explicitly the kind of roofing plates they want. It is not sufficient for specifications to simply require "stamped sheets," but the actual net weight of the plates contained in the boxes, together with other particulars, should be specified, so as to overcome the liability of defective sheets working their way in on the job.

A SUBSTITUTE FOR PLATINUM IN INCANDESCENT LAMPS.

IT IS necessary to use platinum for the leading-in wires of incandescent lamps for the reason that platinum is the only conductor that has the same coefficient of expansion as glass. If other metals are used, they do not expand at the same rate as the glass when the lamp warms up, and the result is that cracks, or openings, occur at the point where the leading-in wires are sealed in, thus admitting air and destroying the vacuum. Many attempts have been made to discover some alloy that would be much cheaper than platinum and serve the purpose equally well, but so far none of these alloys seem to have proved successful. A new alloy has been brought out, in France, by L. C. Dumas, and it is claimed that this alloy has almost exactly the same coefficient of expansion as glass. It is said to consist of an alloy of 45 per cent. of nickel with 55 per cent. of steel, though the composition of the steel is not stated. Such an alloy would be very useful, as it would render lamp manufacturers independent of the use of platinum, which is a scarce and valuable metal. The amount of platinum used in a modern incandescent lamp is, however, very small, so that it cannot be expected that the reduction in the cost of lamps will be as great as some people seem to imagine.

Such an alloy would also be very useful in the construction of X-ray tubes, or, in fact, in any place where it is necessary to carry a conductor through glass. It is to be hoped that this new material will be capable of doing the work claimed for it.

A GREAT DISCOVERY.

George McC. Robson, M. A.

Preparation of the Principia—Its Scope and Method—Synopsis of First Two Sections.

> **Fervent in doing well, with every nerve**
> **Still pressing on, forgetful of the past,**
> **And panting for perfection.**
>
> —*Thomson.*

In November, 1684, Halley, having received the promised communication from Newton, made a second journey to Cambridge, and strongly urged Newton to allow the work on which he was then engaged to be entered on the register of the Royal Society, in order that his priority in the discoveries might never afterwards be called in question. Accordingly, a paper by Newton entitled *Propositiones De Motu* ("Propositions Concerning Motion") was entered on the register of the Royal Society, and produced at their meeting of December 10. This paper is, in fact, the manuscript of the lectures Newton delivered during that term in the University, and contains the germ of his Principia. This paper is of great value to the mathematical antiquary, but is not of the same interest to the general reader, because the same ground is covered more thoroughly in the Principia; we shall, therefore, give no account of the three definitions, four hypotheses or assumptions, two lemmas, and eleven propositions of which it consists, but proceed at once to speak of the Principia, which is universally ranked as one of the greatest classics in the literature of science, and which, in England, has been read and admired by the weaver at his loom as well as by the student in his chamber.

As soon as the end of the University term relieved Newton from the active duties of his chair, he began the preparation of the work he had promised to the Royal Society—then referred to as *Propositiones De Motu*, but now known as the Principia. It would be a mistake to suppose that the discoveries embodied in the Principia were already made, and that the task before him was merely to write out the propositions with their demonstrations. Even at this period he had no idea of the magnitude and completeness of the work he was about to do, and he supposed that the promised treatise would be little more than an amplification of the *Propositiones De Motu*. As early as February, 1685, he complained that the work had occupied more time than he expected, and much of it to no purpose. As he proceeded with the work, the subject opened more and more to him, and he delayed the publication in order more thoroughly to investigate certain questions. The Principia was completed in less than two years, and the time actually occupied in its composition was not more than a year and a half.

It is hardly possible for ordinary men to realize how completely Newton concentrated his mind upon his investigations during these two years of ceaseless thinking and calculating; he says himself that his discoveries were made by constantly thinking of the subject, and brooding over it till the first dawnings opened slowly into a full and clear light. This great work required not only transcendent genius, but the greatest strength of will and steadiness of purpose; and the lines, quoted at the head of this article, from the poem on Newton's death, seem to us singularly graceful and appropriate. During the preparation of the Principia, Newton was so completely absorbed in meditation that his mind appears to have been almost oblivious of his body; the most extraordinary stories of his absent-mindedness at this period are vouched for by unimpeachable authorities. It was not unusual for him to spend a large part of the day, half-dressed, on the side of his bed; and his servant had to exercise constant watchfulness to compel him to take sufficient food. On one occasion, Dr. Stukeley, making a call, found Newton's dinner upon the table, covered up to keep it warm till he could be induced to come to the table; the doctor lifted the cover, ate the chicken, and replaced the cover over the bones. A little later Newton came into the room, and, after exchanging the customary compliments with Dr. Stukeley, sat down to dinner; when he uncovered the bones, he remarked, "I thought I had not dined, but I find I have."

The work produced by such Herculean labor is at once a profound treatise on mechanics, and a compendium of great discoveries in physical astronomy; it abounds

in beautiful and powerful mathematical artifices applied to the most interesting problems of dynamics. The fundamental principles of mechanics that were first clearly stated and established in the Principia are of vital importance in the most practical as well as in the most theoretical departments of science. It cannot fail, therefore, to be interesting to describe, as clearly as may be without the use of mathematics, the scope and method of this great book.

In the preface to the first edition, Newton sets forth the object of the work, and explains that it is entitled "The Mathematical Principles of Natural Philosophy," because "all the difficulty of philosophy seems to consist in this—from the phenomena of motions to investigate the forces of nature, and then from these forces to demonstrate the other phenomena." Accordingly, the first and the second book of the Principia are devoted to the discussion of the laws of force and motion, and constitute a treatise on what, in English books, is commonly called the science of *dynamics*, but is more properly styled *kinetics*. In the third book these laws are applied to explain the phenomena of the solar system.

The first book is taken up with the discussion of the motion of particles and of bodies in free space, that is, in space that is not occupied by any resisting medium. In the second book he treats of motion in a resisting medium, of hydrostatics, and of hydrodynamics. In the last section of the second book, it is shown that the Cartesian vortex theory is inconsistent with observed facts and with the laws of motion. The first and the second book both bear the subheading *De Motu Corporum* ("Concerning the Motion of Bodies"). The third book, which contains the applications to astronomy, is entitled *De Systemate Mundi* ("Concerning the System of the World"). In the beginning of this book he says: "I had indeed composed the third book in a popular manner, that it might be read by the many; but afterwards, considering that such as had not sufficiently entered into the principles could not easily discern the strength of the consequences, nor lay aside the prejudices to which they had been many years accustomed, therefore, to prevent disputes that might be raised on such accounts, I chose to reduce the substance of this book to propositions, in the mathematical way, which should be read by those only that had mastered the principles established in the preceding books."

In 1728 there was published in London a book with the title "A Treatise of the System of the World. By Sir Isaac Newton." This professed to be a translation of the popular work to which allusion is made in the extract quoted above; the original Latin was published in 1731. It appears highly probable that this book is spurious, and that it was concocted by some unscrupulous publisher as soon as Newton was dead and could not disown it. In confirmation of this suspicion, it may be noticed that it appeared without the name of any editor, and without any allusion to Newton's recent death; and it is utterly inconsistent with what is known of Newton's character that he should imagine, as stated in this alleged treatise of his, that the central fire in Numa's temple of Vesta was intended to symbolize the sun as the center of the solar system, in accordance with the Copernican theory.

Since the laws of motion can be expressed only in terms of space and number, mechanics is necessarily a mathematical science; it is utterly absurd to pretend that there can be any useful science of mechanics that is not based upon mathematics. The science of mechanics must be developed by mathematical reasoning, and the only question is whether the mathematics employed shall be purely geometrical, purely analytical, or partly analytical and partly geometrical. In the geometrical method, geometrical magnitudes are not represented by algebraic symbols, and all numbers, such as those that measure time and force, are represented by spaces. In the analytical method, on the other hand, all quantities including geometrical magnitudes are represented by algebraic symbols; this method is far more powerful and fertile in results than the geometrical, and since the time of Euler, mechanical science has been predominantly analytical.

Euler and Lagrange and many other eminent men relied almost exclusively on symbolical methods in the solution of mechanical problems, and did not pretend to be able to explain the meaning of every step in the investigation. On the other hand, Newton, at every step in an investigation, had the aim and purpose of his operations clearly before his eyes; hence, it happens that the solution of a problem by Newtonian methods frequently gives a clearer view of its meaning and the principles underlying it than the solution of the same problem by the methods of Euler or Lagrange would give. But as Euler himself points out, it is more difficult to apply

Newtonian methods to new problems. Even when Newton had arrived at his discoveries analytically, he preferred to employ geometrical methods in the exposition of them, and, therefore, the demonstrations in his Principia are very largely geometrical.

Besides his personal preference, Newton had another motive for adopting geometrical methods in the Principia; many of the theorems had been obtained by the calculus of fluxions (differential and integral calculus), and he was unwilling to put forth startling physical discoveries supported by demonstrations based on a new and unknown calculus. All questions relating to quantities that can increase or diminish only by definite amounts are treated by the methods of ordinary arithmetic and algebra. Such quantities are called *discrete* quantities; for example, a pile of cannon balls is a discrete quantity, because it cannot be increased by any smaller amount than one ball at a time. But a period of time does not increase from five hours to ten hours by the successive addition of any finite interval, as an hour, a minute, or a second; quantities of this kind are said to be *continuous*. Problems relating to continuous quantity can be treated analytically only by using something equivalent to the calculus of fluxions; when treated geometrically, these problems are reduced to drawing a tangent to a curve, finding the length of an arc of a curve, finding the area of a curvilinear figure, or some such geometrical problem. Before the time of Newton, geometers had employed two methods in attempting the solutions of such problems; the ancient Greeks had used the method of *exhaustions*, and the mathematicians of the seventeenth century used the method of *indivisibles*.

The method of exhaustions is attributed to Eudoxus (408 B. C.), an Athenian mathematician; it depends on the principle that *if from the greater of two quantities there be taken away more than its half, and from the remainder more than its half, and so on, there will ultimately remain a magnitude less than the smaller of the two original magnitudes.* Euclid made this the first proposition of the tenth book of his "Elements of Geometry," but his modern editors have transferred it to the beginning of the twelfth book. This method is not adapted for the discovery of new truths, and was employed by the Greeks merely to give a logical demonstration of a proposition previously discovered by some other means. The demonstration was completed by a *reductio ad absurdum*—that is, by showing that any other statement than that contained in the proposition must be false. This method is perfectly logical, but is exceedingly tedious and barren of results.

The first suggestion of the method of infinitesimals, which underlies the method of indivisibles, was given by Antiphon, the well-known opponent of Socrates. In attempting the quadrature of the circle, he first inscribed a square in the circle; then, by bisecting each quadrant, he obtained a regular inscribed octagon, then a regular polygon of sixteen sides, and so on, until at length he supposed a regular inscribed polygon of an infinite number of sides to be arrived at, and this inscribed polygon, he said, is coincident with the circle. The Greek critics of Antiphon repudiated the idea that a polygon could ever be anything but a rectilinear figure, and the doctrine that a curve could be regarded as made up of an infinite number of infinitely short straight lines was not revived till the time of Kepler, who used this doctrine freely. The principle of indivisibles was first definitely enunciated by Cavalieri, an Italian mathematician, in 1629. He asserted that a line is made up of an infinite number of points, each without magnitude; a surface is made up of an infinite number of lines, each without breadth; and a volume is made up of an infinite number of surfaces, each without thickness. Subsequently, in deference to the criticism of Guldinus and others, he modified the statement of his principle; though his doctrine even in its amended form is not free from objection, yet it was a valuable contribution to mathematics, and enabled the mathematicians of the seventeenth century to discover many important theorems.

As already stated, Newton felt debarred from using fluxions in his Principia; the method of exhaustions he rejects "in order to avoid the tediousness of deducing perplexed demonstrations *ad absurdum*"; and the method of indivisibles, though it shortens and simplifies the demonstrations, he declares to be inadmissible because it is illogical. In order, therefore, to be able to demonstrate his propositions without using any of the methods enumerated, he devotes the first section of the first book to the exposition of the method of *prime and ultimate ratios*, or what is now called the method of limits. The eleven lemmas of this section contain an excellent geometrical account of the method of limits; and the scholium, with which the section closes, contains a comparison of the

method of limits, the method of exhaustions, and the method of indivisibles.

The introduction to the Principia, which precedes the section on prime and ultimate ratios, contains eight definitions or explanations of words in the sense in which he

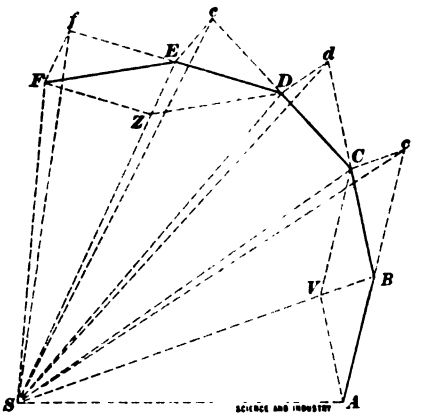


Fig. 1.

wishes them to be understood, and three axioms or laws of motion. The scholium, with which the introduction concludes, is on the history of the laws of motion, and refers to Galileo's investigation, by the laws of motion, of the paths of projectiles. Those of the words defined that we shall have occasion to use are now familiar to every person, and it is not necessary to give his explanations of them; the three laws of motion as stated by him have appeared in a previous part of this article. There has been much criticism of the form in which Newton expressed the laws of motion; but the important point is that, after ages of endeavor, these laws were at length clearly grasped and definitely stated. The best form of expression for these laws is a metaphysical, rather than a physical, question, and its settlement may be left to those whom Galileo terms the "paper philosophers."

The second section of the Principia is on the determination of centripetal forces, or forces directed toward a fixed point. The demonstrations do not apply to bodies of finite size, but only to material particles; the theorems, however, are approximately true for any body whose dimensions are so small in comparison with its distance from the center of force that they can be neglected. The first proposition is that *a body under the action of a central force will describe areas by the radii drawn to the center of force which are proportional to the times of describing them;* in other words, Kepler's second law is true for a particle moving under the action of any central force. In Fig. 1 we reproduce the figure upon which Newton proved this fundamental proposition; for the benefit of the non-mathematical reader we paraphrase into popular language, without attempting to preserve mathematical rigidity, the reasoning by which he proved the theorem.

In Fig. 1, S is the fixed center toward which the force acts. Now suppose that the central force toward S does not act, and suppose the time to be divided into a number of equal intervals, and suppose that in the first of these intervals the particle moves from the point A to the point B. Since the particle is not acted on by any force, by the first law of motion, the path $A B$ will be a straight line. If uninterrupted, the particle would, in the second interval, proceed directly to c along the line $B c$, which is equal to $A B$; so that, by the radii $A S$, BS, and cS, the equal areas $A S B$ and $B S c$ would be described in these equal intervals. But suppose the particle, on arriving at B, receives a blow directed along the line BS and is thereby deflected from the line $B c$ and compelled to continue its motion along the line $B C$. Through the point c let the line $c C$ be drawn parallel to BS, and meeting $B C$ in C, thus determining the point C. Then it is an immediate consequence of the laws of motion that, at the end of the second interval, the particle will be found at C. The triangles $B S C$ and $B S c$ are equivalent, because they have the same base $B S$, and the altitude of each is the perpendicular distance between the parallel lines $c C$ and $B S$; but the triangle $B S c$ is equivalent to $A S B$; hence, also, $B S C$ is equivalent to $A S B$. In like manner, if the particle receives a blow directed toward S at each of the points C, D, E, etc., the triangles $C S D$, $D S E$, etc. are each equivalent to the triangle $A S B$. Therefore, by addition, any sums $A S D C B$, $A S E D C B$ of the areas of these triangles are proportional to the times of describing them. Now, the greater the number of intervals into which the time is divided, and the smaller each interval, the more nearly does the particle approach to the condition of a particle moving under the action of a continuous force, and the more nearly does the broken line $A B C D E$ approach to coincidence with the curve described under the action of a steady force; and, no matter how small the equal intervals into which the time is divided, the areas described in any two periods are proportional

to the periods occupied in describing them.

But still the path of the particle is a broken line and not a curve, and the force deflecting it from rectilinear motion is a succession of blows and not a continuous force. To bridge this gulf the adherents of the doctrine of indivisibles would have said that when the number of intervals is infinitely great, and each interval infinitely short, the broken line is actually a curve, and the succession of blows at infinitely short intervals is a steady force. The method of exhaustions would involve a tedious *reductio-ad-absurdum* argument. By the method of limits, which Newton had established on a satisfactory basis, he was able to argue logically from the case of a particle, compelled to move in a broken line by a series of blows, to the limiting case of a body moving in a curve under the action of a continuous force, and to conclude that in this case, also, there is equable description of areas. This is the spirit of the first satisfactory solution that was ever given of a problem relating to the motion of a body acted on by a central force.

By the same method, it is easily shown that there is no equable description of areas about a point S unless the force acting on the particle is constantly directed toward S. Suppose a body, not acted on by any force, to move along the line AB, Fig. 2, and on reaching B to receive a blow along the line OB, which does not pass through S. Suppose that this blow compels the body to proceed along the line BP. Produce AB to C, making BC equal to AB. But for the blow the body would be at C at the end of the second interval; but the effect of the blow, combined with the velocity the body had on reaching B, causes it, at the end of the second interval, to be at the point P, which is found by drawing CP parallel to OB to meet the line BP. In this case, the area BSP is not equal to BSC, and, therefore, the area BSP is not equal to ASB.

In the second proposition, Newton proves that every body that moves in a curve and describes, about a fixed point, areas proportional to the times, is acted on by a force directed toward that fixed point. In a scholium to this proposition, he points out that a body may be urged by a central force compounded of several forces; in such a case the meaning of the proposition is that the resultant of all the forces tends to the fixed point. The third proposition shows that every body that describes, about the center of another body, areas proportional to the times, is acted on by a force that is the resultant of a central force toward the center of that other body, and all the accelerative forces acting on that other body.

Assuming that the dimensions of the bodies of the solar system can be neglected in comparison with the distances between them, these propositions enable us to assert that Kepler's second law proves that the planetary motions are governed by a central force directed toward the sun; and that the converse is also true.

In the fourth proposition, it is proved that if a body describes a circle of radius r with a uniform velocity v, the centripetal force is $v^2 \div r$; from this proposition, assuming the planetary orbits to be circles concentric with the sun, he shows, by the method given in the October number, that the force controlling the planets varies inversely as the square of their distances from the sun.

Proposition ten proves that when a body describes an ellipse under the action of a force to the center of the ellipse, the force varies directly as the distance of the body from the center of the ellipse. In a scholium to this proposition, he says that if the ellipse degenerates into a parabola by having its center removed to an infinite distance, the body will move in that parabola, and the force become an equable force, tending to a center infinitely remote; in other words, a body will describe a parabola under the action of a constant force acting parallel to the axis of the parabola; thus he deduces Galileo's theorem of parabolic motion as a

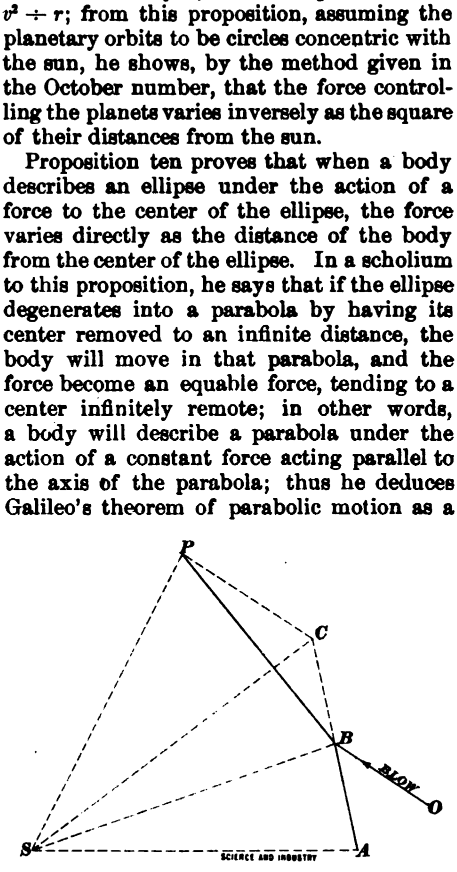


FIG. 2.

limiting case of elliptic motion. In the same scholium he shows that a body will describe a hyperbola under the action of a repulsive force emanating from the center of the hyperbola, and varying directly as the distance. This concludes the second section of the Principia.

SATURATED STEAM.

Wm. Gratz.

Relation Between Temperature and Pressure—Compression and Expansion of Saturated Steam—Superheating by Expansion.

CONSIDER a cylinder, Fig. 1, containing a piston P that fits the cylinder steam-tight and air-tight, but is free to slide axially. No friction is supposed to exist between the cylinder walls and the sides of the piston; and the piston itself is supposed to have no weight. The cylinder contains 1 pound of water. Let us now start a fire underneath the cylinder and observe what will happen. We know that the water will be gradually heated until it reaches the boiling point, after which the temperature will remain constant. The application of heat after this point is reached produces a change in the state of the water—the heat gradually turns it into steam. This steam coming off from the water is *saturated steam*. Since the steam occupies a greater space than the water from which it is formed, the piston will have to move upwards to make room for the steam. As long as there is any water in the cylinder below the piston, the steam in the cylinder is saturated steam, but it may be either dry or wet saturated steam, depending on whether there are any particles of water entrained, i. e., held in mechanical suspension in the steam. When water is entrained, the steam is *wet* saturated steam; otherwise it is *dry* saturated steam. Now, let heat be supplied until all the water has been turned into steam; the cylinder will then contain dry saturated steam. But dry saturated steam, according to the definition given above, can also exist when the cylinder contains water, a fact that should not be lost sight of.

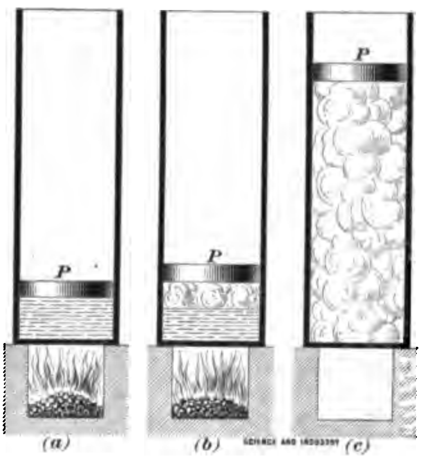


Fig. 1.

Saturated steam, whether wet or dry, is distinguished by the fact that it has *one* temperature for any given pressure. In the example above, and under the suppositions stated, the pressure on the water in Fig. 1(a), the pressure of the steam and on the water in (b), and the pressure of the dry saturated steam in (c) is, in each case, equal to the pressure of the atmosphere on the upper surface of the piston. If this pressure is 14.7 pounds per square inch, the boiling point of the water and the temperature of the saturated steam will be 212° F. Conversely, saturated steam having a temperature of 212° F. has a pressure of 14.7 pounds per square inch, and it cannot have any other pressure as long as its temperature remains 212°.

If we should place on the piston a weight W, as shown in Fig. 2 (a), (b), and (c), the weight of it being equal to the total pressure of the atmosphere on the piston, we would have a pressure of 2×14.7 pounds per square inch on the water below the piston. The water, under these conditions, would begin to change into steam when it attained a temperature of 249° F. The temperature of saturated steam having a pressure of $2 \times 14.7 = 29.4$ pounds per square inch, is, therefore, 249° F. And conversely, the pressure of saturated steam whose temperature is 249° F., is 29.4 pounds per square inch.

Likewise, saturated steam of any other pressure has *one* certain temperature corresponding to that pressure. These temperatures for given pressures have been ascertained by careful experiments, and, in conjunction with other information relating to saturated steam, are compiled in a tabular form known as the *steam tables*. Consequently, we can, by consulting them, find the temperature of any saturated steam under consideration when we know its pressure; or we can find its pressure if we know its temperature.

Fig. 3 (a) shows our cylinder partially

filled with saturated steam and water under the pressure of the atmosphere. Assume that we have removed the fire from under the cylinder. Let us see now what will happen if we place on the piston the weight *W*, mentioned in connection with Fig. 2. The piston, under the influence of the weight, will move down, compressing the steam until the pressure of the steam below the piston becomes equal to the sum of the pressure of the atmosphere and the pressure due to the weight on the top of the piston. When these pressures become equal, the piston will stop its downward motion and will occupy a position like that shown in Fig. 3 (*b*), i. e., nearer to the bottom of the cylinder than shown in Fig. 3 (*a*). We will now find that there is more water

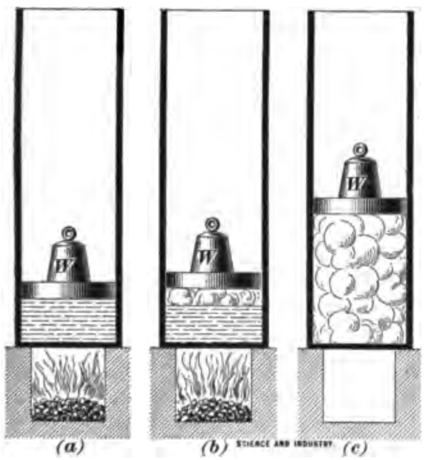


Fig. 2.

in the cylinder than there was before the weight *W* was placed on the piston. This fact leads us immediately to the conclusion that during the compression some of the steam contained above the water, in Fig. 3, must have condensed back into water. We would also find, on inserting a thermometer in the cylinder shown in Fig. 3 (*b*) that the temperature of the water and steam is no longer 212° F., which was the case before the weight *W* was added, but that it is 249° F. As we have removed the heat from under the cylinder, the question naturally arises, Where did the heat that raised the temperature of the contents of the cylinder come from? We know that to evaporate water at the boiling temperature, a certain amount of heat, known as *latent heat*, must be absorbed before the water will change into steam. Conversely, when steam is changed back into water, it gives up its latent heat. When the weight *W* was placed on the piston the steam below the piston was compressed, and some of it was condensed back into water. Assume that the cylinder and piston are perfect non-conductors of heat. Then, the latent heat of the steam that was condensed was consumed in heating the contents of the cylinder from 212° F. to 249° F. If we were now to remove the weight *W* from the piston [see Fig. 3 (*b*)], the pressure

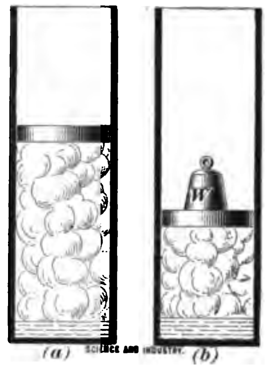


Fig. 3.

on the upper surface of the piston would be decreased to 1 atmosphere, that is, 14.7 pounds per square inch. The pressure on the under side being equal to 2 atmospheres, that is, 29.4 pounds per square inch, the result would be that the piston would be raised to its former position in Fig. 3 (*a*)—that is, until the pressure below the piston is equal to that of the atmosphere. In this condition the contents of the cylinder would again have a temperature of only 212° F. This leads us to the question, What has become of the amount of heat that kept the temperature of the mixture at 249° F.? This heat has evaporated some water. It has evaporated exactly the same amount of water as was condensed by the compression due to the weight *W*.

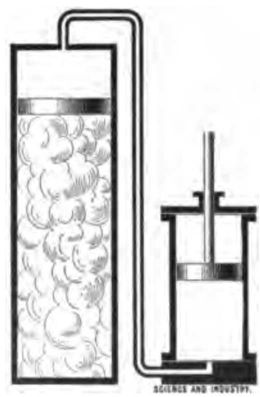


Fig. 4.

If we compress the dry saturated steam at (*c*), Fig. 1, by placing a weight *W* on the piston, the result will be that some of the steam condenses; the latent heat of this condensed steam will raise the temperature of the water and saturated steam in the cylinder. Exactly the same changes occur as when steam, in contact with the water from which it is formed, is compressed.

Suppose, however, we were to connect the cylinder, shown in Fig. 1 (*c*), containing dry saturated steam, with an air pump, shown in Fig. 4, and lessen the pressure on the top of the piston by pumping out some of the air. The piston would rise as the air was being pumped out, and the pressure of the steam would decrease. But as the amount of heat contained in the steam in the cylinder does not change while the pressure decreases, it follows that now the steam will have a temperature higher than that corresponding to the pressure. Steam in this condition is said to be *superheated*. Hence, by decreasing the pressure of dry saturated steam, superheated steam is produced. But superheated steam may also be produced by keeping the pressure constant and adding heat to the steam. Naturally, this superheating destroys the relation between the temperature and the pressure given in the steam tables.

From the above it must not, however, be inferred that, if dry saturated steam were introduced into the cylinder of an engine, superheating would necessarily result. The heat that would produce the superheating, if the conditions were such as indicated in the cylinder shown in Fig. 4, would, in an actual engine, be utilized in doing work on the piston. If the work done on the piston, by the expanding steam, is less than that corresponding to the quantity of heat available for superheating when no outer work whatsoever is being done in expanding, the steam may become superheated to a slight degree. If, however, as is generally the case, the heat required to do the work is quite large, then not only will there be no superheating, but some of the steam will actually condense and give up its latent heat. That is, part of the required work will be done by expansion, and the remainder by the latent heat given up by the condensed steam.

NEW YORK BUILDING LAW.*

SUMMARY OF ITS CHIEF REQUIREMENTS IN THE BOROUGHS OF MANHATTAN AND THE BRONX.

WE REPRINT herewith the second portion of a summary of the New York building law, compiled by "The Evening Post," New York City, and issued in circular form by The Union Surety and Guaranty Company.

Iron Shutters (*continued*).—All shutters opening on fire-escapes, and at least one row, vertically, in every three rows on the front-window openings above the first story of any building, shall be so arranged that they can be readily opened from the outside by firemen.

Fire-Escapes.—Every dwelling house occupied by or built to be occupied by three or more families above the first story, every hotel or lodging house more than three stories in height, every boarding house containing more than fifteen sleeping rooms above the basement, every factory, mill, manufactory, or workshop, hospital, asylum, or institution for the care or treatment of individuals, every building used in whole or in part as a school or place of instruction or assembly, and every office building five stories or more in height, must be provided with such fire-escapes, stairways, or other means of egress in case of fire as shall be directed by the Superintendent of Buildings. Every fire-escape must be kept in good repair and properly painted by the owner of the building upon which it is erected.

Wires and Gas Brackets.—Electric wires for furnishing light, heat, or power, led into any building, shall be arranged with suitable appliances to cut off the current on the outside of the building. All such wires must be properly insulated, and must comply with the rules and regulations of the Bureau of Electrical Appliances in the Fire Department. Gas brackets must be placed at least 3 feet below any ceiling or woodwork, unless they are properly protected by a shield, in which case the distance shall not be less than 18 inches. Swinging or folding gas brackets shall not be placed against any stud partition or woodwork. Gaslights placed near window curtains or any other combustible material must be protected by a proper shield.

Plumbing and Drainage.—The plumbing and drainage of all buildings shall be executed in accordance with plans previously approved in writing by the Superintendent of Buildings.

Fire Limits.—The erection of frame buildings, with the exceptions hereafter noted,

* The first portion of this summary was printed in the September, 1899, issue of "The Building Trades Magazine."

is prohibited south of One Hundred and Nineteenth Street, west of the Harlem River, not including the district west of the Boulevard above One Hundred and Sixty-Fifth Street; and on the east side of the city south and west of a line beginning on the Harlem River at One Hundred and Forty-Ninth Street, running easterly to Third Avenue, thence northerly to Westchester Avenue, thence easterly to Trinity Avenue, and thence southerly to the East River or Bronx Kills. North, west, and east of these limits no frame building to be occupied as a stable, workshop, or manufactory shall be built more than two stories, or 25 feet, in height. North and east of the limits three-story frame dwellings, with shingle roofs and 12-inch brick foundation walls, may be built to a height of 35 feet. Small outhouses, not over 8 feet high and not exceeding 150 square feet in superficial area, may be built of wood, but the roofs must be covered with metal, gravel, or slate. Sheds not over 15 feet high, open on at least one side, may also be built of wood, with the sides and roof covered with fireproof material, but no fence shall be used as the back or side of any such shed. Fences of wood must not be over 10 feet high, and wooden signs must not be over 2 feet high on any building.

Filing of Plans.—Before the erection or alteration of any building or part of any building is begun, the owner or his agent or architect shall file in the Department of Buildings a complete copy of the plans of the proposed work, with a detailed statement in writing of the specifications, and obtain a permit for the same. The principal office of the Department of Buildings is in the Borough of Manhattan. There is a branch office in the Borough of Brooklyn, and a branch office may be established in any of the other boroughs, at the discretion of the Board of Buildings.

THE NEW CHARTER PROVISIONS RELATING TO BUILDINGS.

Commissioners. — Under the charter of Greater New York the head of the Department of Buildings is called the Board of Buildings, and consists of three Commissioners, one of whom has administrative jurisdiction in the Boroughs of Manhattan and Bronx (New York), one in the Borough of Brooklyn, and one in the Boroughs of Queens and Richmond (Long Island City and Staten Island). Each Commissioner is required to be a competent architect or builder of at least 10 years' experience; and is appointed by the Mayor, who designates one, when appointed, as President of the Board. The Board is empowered to establish general rules and regulations for the administration of the department, and such other rules and regulations as were authorized by law at the time of the adoption of the new charter, to be established by the Superintendent of Buildings in the city of New York and the Commissioner of Buildings in Brooklyn.

Continuation of Former Laws.—All the laws in effect at the time of the passage of the new charter concerning, affecting, or relating to the construction, alteration, or removal of buildings or other structures in any of the municipal and public corporations included within Greater New York are continued in full force and effect, except in so far as the same are inconsistent with or are modified by the new charter.

Provision for New Building Code.—The Municipal Assembly is empowered to establish, and from time to time to amend, a code of ordinances to be known as the "Building Code," providing for all matters concerning, affecting, or relating to the construction or removal of buildings in Greater New York. It may, for the purpose of preparing such code, appoint and employ a commission of experts. Upon the establishment of such code, the old New York and Brooklyn building laws and the old ordinances relating to buildings in other parts of the Greater City thereby become repealed. The provisions of such code must conform to all general laws relating to buildings.

Decisions and Appeals. — Each Commissioner is empowered to pass upon any question relative to the mode, manner of construction, or materials to be used in the erection or alteration of any building within the borough or boroughs under his jurisdiction. If the owner affected is dissatisfied with the decision of any one Commissioner upon such a question, he or his authorized agent may make an appeal in any case where the amount involved by such decision shall exceed the sum of one thousand dollars. In the Borough of Brooklyn and in the Boroughs of Queens and Richmond, appeals shall be taken to the Board of Buildings. In the Boroughs of Manhattan and the Bronx, appeals are to be made to the Board of Examiners, of which the Commissioner for those boroughs is *ex officio* a member and the chairman. The other members of the Board of Examiners

are one representative of the New York Chapter of the American Institute of Architects; one representative of the New York Board of Fire Underwriters; two members of the Mechanics' and Traders' Exchange of New York, one of whom must be a master mason and the other a master carpenter; one member of the Society of Architectural Iron Manufacturers of New York; one member of the Real-Estate Owners' and Builders' Association of New York, who must be an architect or builder; one member of the New York Real-Estate Exchange, Limited, who must be an architect or builder; and the chief of the Fire Department.

Areas to be one-fifteenth of the width of street, but in no case wider than 5 feet in the clear, to be enclosed with a railing.

Stoops or steps not to extend more than one-tenth part of the width of street, but in no case more than 7 feet.

Bay windows not to extend more than 1 foot from the house line.

Cellar doors not to extend more than one-twelfth the width of any street, but never more than 5 feet.

THE END.

THE GEOLOGY OF THE WEST.

(*Concluded from the October, 1899, Number of "The Mechanic Arts Magazine."*)

Prof. Arthur Lakes.

FROM DENVER TO SAN FRANCISCO—THROUGH THE WASATCH MOUNTAINS—THE GREAT BASIN. HOW IT WAS FORMED—THE GREAT SALT LAKE—UTAH.

IN OUR previous article we had reached the coal town of Evanston, on the border line between Wyoming and Utah. From here our course turns abruptly west. We can see, not far off, the snow-capped summits of the Wasatch Range, and gladly turn our backs on the dreary sage-brush lake beds of Wyoming, with all their interesting fossil remains, and plunge down the ever-deepening Echo Cañon, between vertical walls of sandstone, along the course of the Weber River, which cuts a clear section through the heart of the Wasatch Range.

The cañon walls, which rise over 2,000 feet on either side, are composed of the same shore-line materials that compose the Green River beds of Wyoming, namely, coarse red and yellow conglomerates and large pebbles. The walls are horizontal for some miles, but as we approach the mountains they dip 5 degrees, which indicates that the mountains have risen since these rocks were formed, and are probably still rising. Later on, limestones and dark shales appear cropping up from beneath the horizontal beds at an angle of from 30 to 40 degrees; and, as we go still farther down the cañon, vertical rocks of a red color appear. These three kinds of rocks are what geologists call Tertiary, Cretaceous, and Jurassic, and they lie unconformably upon one another. At the entrance to Weber Cañon, two singular blade-like rocks, a thousand feet high, jut out of the side of the cañon, with a deep trench between them. This is called the "Devil's Slide"; it is simply two hard vertical sheets of rock, with softer shale rock between them that has been hollowed out by water, or perhaps by the friction of the satanic "coasting." Down we go, plunging deeper into the narrowing cañon, through vertical quartzite and limestone, and we finally enter the granite core of the range, from which we soon emerge on the other side of the mountain.

Looking back, we notice that this western side is much steeper than the eastern slope. It is a steep cliff of granite, with broken edges of limestone on the top, and towers some thousands of feet above the town of Ogden, which lies at its base. A brief history of the formations we have passed through will be of interest.

Had Jules Verne desired to penetrate 8 miles vertically into the bowels of the earth, his wish could here have been gratified, for since we left Evanston we have passed through a vertical section of the earth's crust 8 miles in thickness, just as we would have done had we descended that depth into a mine. Strata of a thickness of 40,000 feet have been uplifted to the granite of the Wasatch Range. This crust of the earth is, as we have seen, composed of ordinary sandstones and limestones, and beginning from the lowest, i. e., that nearest the granite,

and ascending to the top, we should find fossils of various kinds, such as shells, plants, and animals, which record the history of the several ages of the earth's life. This great thickness of strata was laid down by water—by seas, lakes, and rivers—at various periods during millions of years, one horizontally on top of the other, and afterward folded and uplifted by the rising mountains.

The order of events was this: A granite reef or low island received the deposits of the ancient ocean; after a great thickness had accumulated, an uplift occurred, and the sea bottoms were raised above the level of the water. Against this uplifted land the Cretaceous sea, which occupied the site of the present eastern and western prairies, beat its waves and deposited its contributions to the land. A second great uplift occurred; the sea was drained off and its basin was occupied by the fresh-water lakes, which in turn deposited their beds—horizontally, of course—against the upturned strata of the land. Since they were deposited a slight rise of the Wasatch has occurred, and these lake beds are tilted 5 degrees also.

It appears, then, that the Wasatch was elevated from the bottom of the sea to its mountain form by three periods of elevation, with pauses between them. This is what the "unconformability" we noticed in the cañon teaches us. When, by folding up, the strata reached their greatest tension, the huge mass broke and slipped down several thousand feet on the west side, causing the present fault escarpment, or cliff, above Ogden, the fallen portion forming the floor of the Great Basin next to be described.

This uplifting, folding, and faulting was gradual, and was probably accompanied by earthquakes. Very modern slips and faults occur along the edge of the Wasatch, marked by a line of hot springs, due perhaps to depth and to the heat of friction, showing that the mountain range is still imperceptibly rising. The Wasatch has another interest: it is along the central line of the great Rocky Mountain uplift, the pivot range, as it were, of the whole mountain system.

The Great Basin.—As we emerge from the cañon a new scene bursts upon us, and we enter a region quite as arid as the one we passed through. The surface of the Great Basin, however, is not like the monotonous plains of Wyoming; it is diversified by a seemingly endless number of isolated peaks, which, in reality, are portions of several distinct mountain ranges. We are looking down into what may truly be called a great basin, the bottom being at least 2,000 feet below the average western prairies in Colorado and Wyoming, and only 3,000 to 4,000 feet above the sea. Even the mountains in this basin attain only a height of 8,000 feet above the sea.

If our vision could reach that far, we could trace the basin 500 miles to its western rim, the Sierra Nevada Mountains, south along the Wasatch Range to Arizona, and north 800 miles to the British possessions. The area of this basin is 208,500 square miles, an area greater than that of France.

The southern part includes the Colorado Desert, which is drained by the Grand Cañon of the Colorado, and also Death Valley, and the region of California and Nevada. The Columbia River crosses this region from east to northwest to the Pacific Ocean. The Colorado River flows southwest to the Gulf of California. Several small rivers drain directly into the basin.

In another sense it is a basin, for all the waters that run into it are without outlet to the sea, and what rain falls in it quickly evaporates. In summer many of the rivers disappear by evaporation and by sinking into the soil. All lakes are salt or alkaline, and their shores are white deserts that are shunned by every living thing. Here and there a few oases occur, as at Humboldt Station, where the eye is refreshed by luxuriant green grass and orchards, occupying a few acres in the midst of alkaline waste. The alkali of the baked soil is blown up in columns by little whirlwinds, and a dozen of these white cyclones can be seen chasing one another over the plain.

The mountains are treeless and destitute of all vegetation save sage brush. Their nakedness allows their anatomical structure to be seen at a glance; they are composed of tilted blocks of granite, lava, and limestone, separated from one another by profound faults; the valleys between the ranges are the beds of lakes that have dried up. Mirages of beautiful lakes and streams often occur, but the lost traveler will perish from thirst, as did the Mormons in Death Valley. In winter the cone-shaped peaks of the mountains are capped with snow, which makes them resemble the tents of an immense army. The Black Rock and Carson Deserts in Nevada are desolate regions, but worse still are the deserts around Great Salt Lake, where not a sign of vegetation grows. Besides the production of salt, borax, and soda, the only industries of this dreary desert are the great mines of the Comstock and Eureka

squares, with grooves about ¼ inch deep, so that, in case it should crack, the fractures will follow the grooves, and thus avoid disfiguring the entire floor.

In hot weather the floor should not be allowed to dry rapidly, but should be occasionally sprinkled.

The figure shows the effect of allowing a cement floor to freeze before the cement has fully set. The layer *a* represents the concrete, while the top coat is shown at *b*. Between the two layers a film of water is formed, which under ordinary circumstances would be gradually absorbed, and would do no harm. If, however, the temperature is below the freezing point, this water is frozen into a cake of ice, and in expanding gradually heaves up the top layer, forming a blister, as shown at *B*. On thawing, this water is absorbed by the under layer, and a hollow chamber is formed, as at *C*. The blister will crack from being walked on, the loose particles are removed, and the surface will ultimately present the appearance shown at *D*.

When cement floors or walks *must* be made in freezing weather, the freezing point can be reduced somewhat by using a solution containing about 3 per cent. of salt for mixing the mortar. This will render operations safe until a temperature of about 28° F. is reached. This is done, however, at a sacrifice of much of the strength of the cement, as it has been proved that any addition of salt to cement is injurious. The salt in crystallizing creates a force in opposition to adhesion, and at the same time possesses the property of attracting moisture.

In laying sidewalks, stakes should be set to grade and to aline with either edge of the walk (allowing for the thickness of the mold boards), the other side being obtained by leveling across, allowing an outward pitch of about ¼ inch to the foot. Straight-edged strips are nailed to the inside of each line of stakes, with the top edges level with them, to form the mold for the concrete. The same precautions to prevent random cracking should be observed as in cellar floors. Usually a walk is ready for use in about 48 hours after completion, and the forms may then be removed.

A walk of this kind can be laid at a cost of about 12 cents per square foot, with Portland cement costing $3.25 per barrel. While it is desirable to use Portland cement throughout, the natural or Rosendale cement may be substituted for it in the concrete layer, thus reducing the cost considerably, without seriously affecting the quality of the walk.

NOTES.

AT THE annual convention of the N. A. S. E., at St. Louis, in September, the St. Louis Steel Wire Brush Company, 318 North Main Street, presented each of the delegates with a handsome memorandum book containing useful and varied information. They have a few left and will take pleasure in mailing one to any engineer that will send his name.

"WOODWORKERS' TOOLS," published by The Chas. A. Strelinger Co., Detroit, Mich., contains descriptions of new tools, the relation of price to quality, etc. An interesting feature is a "Patent Department," containing incidents from the company's experience, information and advice for inventors, etc. As an appendix, the book contains a short treatise on "Geometry for the Trade," and a short glossary of architectural terms, which conveys much reliable information in a condensed form.

THE LATEST catalogue of the Chicago House Wrecking Company, whose advertisement appears elsewhere in this issue, has been received, and from it we learn that the latest move of this enterprising concern has been to purchase the buildings of the Omaha Exposition, and preparations are now being made to take down these buildings and move them to Chicago in such shape that they can be set up complete again if necessary. They are also preparing to bid for the buildings of the Paris Exposition. This is the same company that bought the buildings of the World's Fair, at Chicago, at the small cost of $80,000 for all the materials; they also bought all the materials composing the great Chicago post-office building; besides a long list of other buildings of lesser note. This business is not limited to buying exposition and other large buildings; representatives are stationed in all the large commercial centers to buy large stocks of goods of any kind that may be thrown on the market. Send to the Chicago House Wrecking Company, West 35th and Iron Streets, Chicago, for catalogue No. 165.

CHIPS & SPALLS.

An Exchange for Members of the Crafts.

***Readers are solicited** to send us any inquiries and statements of facts coming under their observation, which they desire to have discussed by their fellow workmen. Any rough pencil sketches, helpful to an explanation, will be touched up, if necessary, and presented in good form.*

Acceptable answers and descriptions of work, other than direct inquiries, will be paid for, when published, at our regular rates.

Communications intended for this department should be clearly addressed " C. and S." Editors of SCIENCE AND INDUSTRY, *Scranton, Pa.*

Write on one side of the paper only. Make sketches on separate sheets of paper. The name of the writer will appear in the magazine, unless otherwise requested.

STRAIGHTENING DRAWING PAPER.

C. T., Cleveland, Ohio.

HAVE YOU ever been bothered with a sheet of drawing paper that has been in a tight roll for some time, and defies all efforts to straighten it? If you have, I will suggest a way, which, though old to many, may be new to some.

Take the refractory sheet by the ends, and while pressing the convex side against the sharp edge of the table, move it gently upward and downward, taking care not to allow the paper to double at the edges. If you have never tried this method before, you will be surprised how neat your sheet will appear, and instead of having all the wrinkles and kinks caused by reverse rolling, it will be as smooth and straight as though just taken from the portfolio.

CONNECTIONS FOR A GAS STOVE.

Economist.

MY WIFE bought a gas stove to cook with during the summer, for our kitchen gets stifling hot when she cooks on the coal stove. The gas company charges 80 cents per thousand cubic feet when we use gas for cooking purposes, but when we use the same gas for lighting purposes they charge $1.25 per thousand cubic feet. The gas company supplies us with a meter, and we are at the expense of fitting it up. I got a plumber to give me the cost of putting in the meter and connecting up the stove complete; but he wanted more for that than I could possibly save in three years by using the meter, so I decided to do the job myself. I worried over the thing for a day or two, and then fell on a good scheme. (See cut.) I simply set the meter on a shelf in the kitchen, and connected the outlet to the stove, and the inlet to a fitting on a gas

bracket, as shown. It works first class, but my gas bills are high, particularly for lighting; I don't understand it, but I suppose it is all right. I would like to know what your readers think of my scheme.

BENDING IRON PIPE FOR STAIR RAILING.

Joseph L. Brown, Baltimore, Md.

TO BEND an iron pipe for a circular stair is not one of the easiest jobs in the world, and I myself have seen many a good mechanic despair at the seemingly impossible undertaking; and yet, to bend that pipe is like everything else—"easy enough when you know how." For the benefit of those that may have to bend pipe hand rail now and

then, and have to get along with "kinks and wrinkles," I wish to explain a simple method, tried and true, and send the accompanying figure to more clearly explain it.

Take an iron bar about 4 in. × ½ in. × 3 ft. 6 in., and give it the helix form corresponding to your stair; or, if you have to use the tool often, give it the average shape of the regular run of your work, probably about 3 feet radius to a 10- or 12-foot pitch. At the top end of the bar, a staple or eye is riveted on, to give a secure hold for the pipe while bending it. Along the bar, drill 11/32-inch holes about 2 inches apart, to receive ⅜-inch pins, ground pointed so as to allow them to be driven in securely, at least on the inside of the curve—the space between the two rows of pins being sufficient to admit the pipe. After having secured the tool to a post or door frame about 6 or 7 feet high, insert your pipe in the staple, and bend downwards and tight to the pins on the inside of the curve for about 6 inches. Then insert pins on the outside, and bend another 6 inches, and so on. After getting accustomed to this method, you will find it unnecessary to insert the outside pins, but it is advisable to use them until you become accustomed to the work. With a well-laid-out form, and some experience and ability for fitting, it is possible to shape a hand rail in from one to three trials. The reason for using pins instead of an angle is only a matter of time saving in the making of the tool.

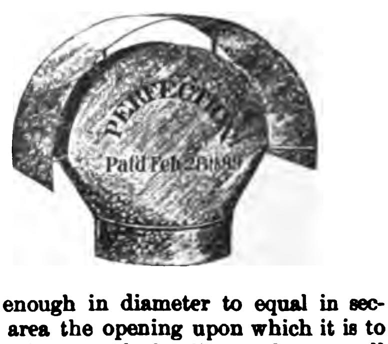
MATERIALS AND EQUIPMENT.

PERFECTION VENTILATOR.

In these days of sanitary improvements and pronounced hygienic attainments, the subject of ventilation stands very prominent, and all apparatus that help to increase the wholesomeness of the air in our homes, schools, factories, ships—yes, and in our street cars, too—are subjects worthy of careful consideration. To have a wholesome atmosphere in any enclosed space we must secure a removal of the air, and when natural ventilation is employed, it is necessary to equip the ventilating flues with some contrivance that will prevent a back current of the foul air and keep out snow, rain, and wind.

The "Perfection Ventilator," shown in the accompanying figure, is designed for this purpose. It is built on scientific principles, and is claimed to be the most up-to-date ventilator yet constructed. The "get-up" is very simple, strong, rigid, and durable. The upper shield is held in position by galvanized malleable-iron staves. It is free from obstructions, and is said to be efficient and storm-proof. Heavy galvanized "Perfection Ventilators" are kept in stock, but copper and brass ones are built to order.

In determining the size of ventilator desired, care should be exercised to get one



large enough in diameter to equal in sectional area the opening upon which it is to be placed. It is a bad policy to place a small ventilator upon a large flue. The stock sizes of "Perfection Ventilators" range from 4 inches to 60 inches in diameter, and the

prices are very reasonable. These ventilators are manufactured by Berger Bros. Company, 231–237 Arch Street, Philadelphia, Pa. Get their estimate on your next order for ventilators and try them.

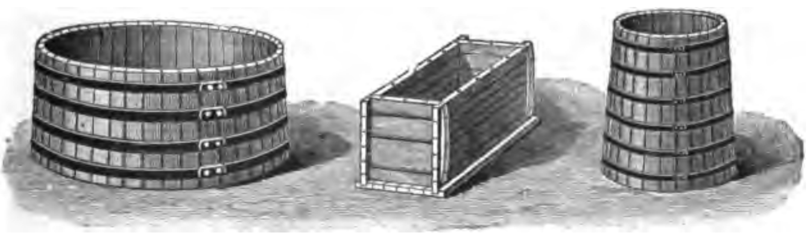
ELBOW FOR FLUSH PIPES.

THE ACCOMPANYING figure shows a convenient elbow for connecting flush pipes to water closets. These elbows are made of rubber, and are particularly adapted for closets in buildings where there is a liability of either closet or flush pipe being shaken by vibrations, due to machinery in motion, or by the settling of the buildings. The elbow shown, which is known as the "Superior," is an especially handy one; it may be shortened by removing the brass shell *S* and cutting off the rubber to any length required. The soft ring *T* furnishes a movable flange, by means of which a tight joint may be made. These fittings can be had bent or straight,

either for flush pipes or vent pipes. They are made in the usual sizes, and the prices range from $6.00 to $12.00 per dozen, according to size.

WOODEN TANKS AND VATS.

THE wood commonly employed in the construction of tanks and vats for holding water is cypress or cedar. The tanks are built of staves, hooped together. Manufacturers usually ship them "knocked down," and if they come long distances, the staves and bottoms are crated in packages convenient for handling, so that they may not be damaged en route. In carload lots, however, they are seldom crated. Small tanks are usually hooped with $\frac{1}{2}$-inch to $\frac{3}{4}$-inch round iron, the bottom hoop being made of flat



iron. Large sizes are hooped with $\frac{1}{8}$-inch to $\frac{3}{16}$-inch soft-steel bands, and all hoops, both round and flat, on the better grade of tanks, are provided with draw-lugs and bolts, a sufficient number of lugs being placed on each hoop to insure a uniform tension and consequent thorough tightness of the staves. The accompanying cut shows three forms of tanks, or rather two tanks and one vat. The tank at the right is the ordinary form used for supplying buildings with water. They are usually set outside the building. The middle tank is convenient for manufacturing purposes as a dye tub, etc.; but if used inside a building for plumbing purposes, it must be lined with copper or lead, to insure tightness. The structure at the left is known as a vat, and is commonly used for manufacturing purposes. Stave tanks should always be set on a good solid foundation. The weight of the tank should not be allowed to rest upon the chimes, that is, the part of the staves that project below the bottom. The tank should always rest on its bottom. If it sets on the chimes, the weight of the water will burst the bottom, or so strain the tank as to cause it to spring aleak.

The directions for setting up a stave tank are as follows: Lay the bottom down on pieces of timber that are large enough to receive it, and high enough that the ends of staves will not rest on anything. It will be noticed that the bottom pieces are marked. These marks should be placed upwards, and come in order. Then the staves should be

set up. Care must be taken to use a wooden mallet in driving the staves together. Iron tools batter the wood too much and cause leakage. The staves should be laid in line by dowels, which are set in as the work of putting up the staves progresses. After the staves are all up, the hoops are put on, starting from the bottom and working upwards, and the tanks are filled with water as soon as possible after setting up.

Wooden tanks are made in different sizes, from 4 feet in diameter by 1 foot 6 inches in depth, containing 141 gallons, and costing about $10.00, to those 20 feet inside diameter, 9 feet 6 inches in depth, containing 2,325 gallons and costing about $270.00 (list price) complete.

The following table is very convenient for determining the capacity of tanks in United States gallons for each foot in depth.

Tanks exposed to the weather should be provided with covers, and they should never be allowed to stand empty, for the sun shrinks the wood and loosens the entire structure. They should not remain empty even during winter, although exposed to the frost. In such cases an arrangement should be placed inside the tank to prevent the expansion of the water, by frost, from bursting the tank.

Diameter. Feet.	Gallons for 1 Ft. Depth.	Diameter. Feet.	Gallons for 1 Ft. Depth.
2′ 0″	23.50	12′ 6″	917.98
2′ 6″	36.70	13′ 0″	992.90
3′ 0″	52.86	13′ 6″	1,070.74
3′ 6″	71.96	14′ 0″	1,151.50
4′ 0″	94.02	14′ 6″	1,235.25
4′ 6″	119.00	15′ 0″	1,321.90
5′ 0″	146.83	15′ 6″	1,411.51
5′ 6″	177.67	16′ 0″	1,504.04
6′ 0″	211.44	16′ 6″	1,599.51
6′ 6″	248.22	17′ 0″	1,697.92
7′ 0″	287.84	17′ 6″	1,799.19
7′ 6″	330.48	18′ 0″	1,903.53
8′ 0″	376.00	18′ 6″	2,010.21
8′ 6″	424.44	19′ 0″	2,120.94
9′ 0″	475.87	20′ 0″	2,350.00
9′ 6″	553.67	25′ 0″	3,570.70
10′ 0″	587.50	30′ 0″	5,287.70
10′ 6″	647.73	35′ 0″	7,189.00
11′ 0″	710.90	40′ 0″	9,367.20
11′ 6″	777.00	45′ 0″	11,893.20
12′ 0″	846.40		

BOOK NOTICES.

THE SLIDE VALVE, SIMPLY EXPLAINED. By W. J. Tennant; revised and enlarged by J. H. Kinealy. Spon & Chamberlain, 12 Cortlandt Street, New York. Price, $1.00.

While there are a number of works in the market that treat on steam distribution as effected by the slide valve, there is none we are acquainted with that presents the subject matter to the reader in the simple manner adopted by the author of this little book. Believing it to be desirable that the reader should have in his possession a model that would give him graphical results, enabling him to compare the actions of different valves under varying conditions, the author has devised a cardboard model that is simplicity itself. In logical order the author treats of the simple slide valve, the eccentric as a crank, advance of the eccentric, the dead center, order of cranks, cushioning and lead, inside and outside lap and lead, compression, double-ported and piston valves, the effect of alterations to valve and eccentric, notes on link motion, notes on very early cut-off and on reversing gears in general, and other similar matters.

JIM SKEEVERS' OBJECT LESSONS ON RAILROADING, FOR RAILROADERS. By John A. Hill. The American Machinist Press, 218 William Street, New York, N. Y. Price, $1.00.

About ten years ago the first one of these sketches appeared in the columns of "Locomotive Engineering," and being well received, enjoyed, and appreciated, was followed by others written along the same lines. These have finally been collected and are reprinted in the present form. While primarily written for railroad men, dealing with phases of life on the foot-board, in the roundhouse, in the shop, and in the office, that the general public knows nothing about, the masterly portrayal of odd characters, and the intimate knowledge of peculiar conditions in the relation between the men outside and the office force that is displayed, coupled with the quaint and palatable style of writing peculiar to the author, makes this book one that can be read, enjoyed, and appreciated by any one, even though they have no special knowledge of railroad work and are not interested in that line of business.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*

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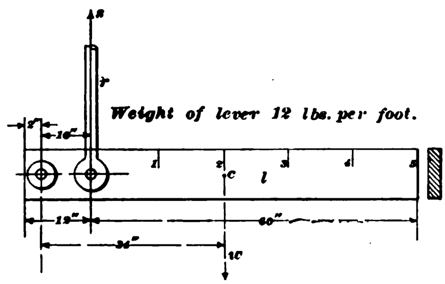
(317) Referring to enclosed sketch, I wish to know how to find the stress on the rod r caused by the



weight of the lever l. In none of the articles on the lever that I have seen in textbooks is the weight of the lever itself considered.

W. C. T., N. Adams, Mass.

ANS.—The weight of the lever l is imagined as concentrated in the center of gravity c, which in this case, the lever being a bar of uniform cross-section throughout, is located in the middle as indicated, and distant from the fulcrum 34 inches. We then have for the stress in the rod r

$$S = \frac{34 \times w}{10} = \frac{34 \times 12 \times 6}{10} = 244.8 \text{ lb.}$$

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(318) (*a*) The enclosed sketch represents Sanford & Mallory's flax brake, with Pilgrim's step motion: taking the coefficient of journal friction as .10, gear-tooth friction as .25, and belt friction as .28, what is the efficiency of the machine for the position given? (*b*) What are the separate forces exerted by each moving piece? Take resistance at the flax-brake rolls as 1,000 pounds. Give analysis graphically. (*c*) What is Dr. Rodenberg's method of using the quadric chain for finding the acceleration of complicated linkages? (*d*) Illustrate Reuleaux's famous law of the relationship of mechanisms.

V. S., Canton, Ohio.

ANS.—We believe the space devoted to Answers to Inquiries, as well as our time, too valuable to give as much of either as will be necessary to answer the above questions, evidently copied, together with the sketch, from a circular issued by the Lehigh University. Besides, we do not consider the matter of sufficient general interest to warrant our giving the answers requested.

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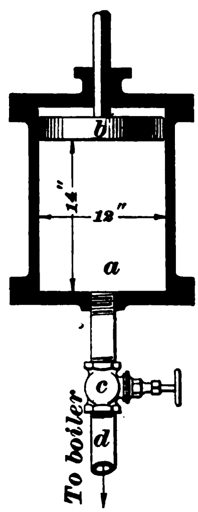
(319) (*a*) Given, a boiler partly filled with water in ordinary working condition, the gauge showing a pressure of 200 pounds, what will be the result if water of the same temperature as that in the boiler is pumped in? How will the steam pressure be affected? Would the temperature of the steam be increased? Explain in general terms. (*b*) Referring to enclosed sketch of cylinder, if the space a is filled with steam at 100 pounds gauge pressure, and the space be decreased by moving the piston b two inches, what will be the pressure and temperature of the steam? Please show calculations.



H. F., Boston, Mass.

ANS.—(*a*) The steam pressure will be increased, and its temperature will also rise correspondingly. (*b*) In engineering practice, calculations pertaining to the expansion of steam are usually conducted on the assumption that the products of the successive pressures and volumes have a constant value; that is, $p\,v = p_1\,v_1$, where p and p_1 are an two successive absolute pressures, and v, v_1 the corresponding volumes; the expansion curve thus obtained is a rectangular hyperbola. The above is true of a perfect gas expanding under a constant temperature, and, although steam is not a perfect gas and does not expand under those conditions, yet it approximates thereto, and the assumption of hyperbolic expansion simplifies calculations. In your case, let $p = 100 + 14.7 = 114.7$ pounds, $v = 14$, and $v_1 = 12$ (since the volumes are proportional to the lengths). Then,

$$p_1 = \frac{p\,v}{v_1} = \frac{114.7 \times 14}{12} = 133.816,$$

or 119.116 pounds gauge pressure.

The temperature of saturated steam of this pressure is about 350° F. We assume from the nature of the dimensions given that you have only the cylinder in mind when talking of compressing the steam. If the valve c were left open, we would require to know the capacity of the pipe d and boiler. If the valve were closed, we would have to know the length of pipe to c and its bore.

***

(320) We are having considerable trouble with some babbitted bearings, which score badly, fill the channels, and then become hot; have tried various kinds of metal, hard and soft. The oil is good, the machine perfectly balanced, the shaft is in first-class condition, and the belt-strain is not excessive; neither is there any undue magnetic attraction. Can you explain matters? E. V. B., Pawtucket, R. I.

ANS.—Assuming that shaft and bearing are in line, so that pressure is fairly distributed, and further

assuming other conditions to be as stated by you, we can only suppose that there is not a free and sufficient supply of oil. Of course, there is a possibility that you are begging the question when you say the oil is *good*. Is it? Very evidently, other conditions being as you say, either the babbitt or the oil is at fault.

***

(321) Figs. 1 and 2 show two methods of driving on an endless-rope haulage. In Fig. 1, one driving pinion drives both drums at once through attached spur wheels; and in Fig. 2, the same pinion drives only one drum, the other being loose. In both cases T represents the tension arrangement. Which of these two arrangements will require the greater amount of tension at T to do the same work?

C. E. B., Birmingham, Ala.

ANS.—The tension balance shown at T (Figs. 1 and 2) serves a triple purpose. (1) It compensates for the lengthening and shortening of the rope, due to expansion and contraction. (2) It obviates undue stresses being brought upon the rope, suddenly, by accident. (3) It gives to the running-off or tail rope the tension necessary to prevent any slipping on the drum, under the load L. For the same work, the tendency to slip is proportional to the arc of contact of the rope upon the driver. In Fig. 1, both drums act as drivers, and hence present double the arc of contact shown in Fig. 2, where one drum only is a driver. Hence, there is an increased tendency to slipping in the arrangement shown in Fig. 2, to obviate which the tension balance must be heavier.

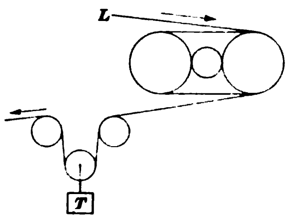


FIG. 1.

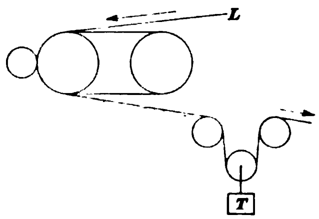


FIG. 2.

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(322) (*a*) Given, a cross-compound air-compressing engine having steam cylinders 16 in. × 26 in. × 30 in., and 18-inch air cylinders. The engine is running at 70 revolutions per minute, compressing the air to a pressure of 90 pounds; what is the pressure on the crankpins and main bearings? (*b*) In using compressed air for an engine, do you economize by cutting off at half stroke, as with steam?

W. D. H., Westville, U. S.

ANS.—(*a*) You say nothing as to whether it is a two-stage compressor or not, nor whether any cooling device is employed. Considerable other data might have been given. Making our own assumption, we estimate the pressure in question as about 10 tons. (*b*) Yes. A given quantity of air is not so valuable, however, for performing work as is the same volume of steam at the same pressure. If we use steam and air (of the same initial pressure) in similar cylinders with same cut-off in each case, the mean effective pressure will be less for the air than the steam. In fact, a cut-off of about 25 per cent. will be required to give the same mean effective pressure as a 20-per-cent. cut-off with the steam.

***

(323) (*a*) What kind of wire will be most durable if exposed to fire? (*b*) In "The Steam-Electric Magazine," June, 1899, Answers to Inquiries, No. 113, you say that a non-condensing engine exhausting into a smokestack will have more back pressure than one exhausting into the atmosphere. In the case of a locomotive, where the exhaust takes place in the same direction as the column of ascending hot air and gases, would not the resistance to the escape of steam, and, consequently, the back pressure, be less than if the exhaust took place directly into the atmosphere? (*c*) What is meant by the expression, "15 inches of vacuum"? (*d*) Can you recommend any one whom I could consult regarding the feasibility, details of construction, etc. of an appliance that might be worth protecting by letters patent?

C. B., Creston, B. C.

ANS.—(*a*) Platinum wire. (*b*) In actual working, the exhaust jet spreads so as to fill the stack at or near the bottom; there is, thus, a certain amount of surface friction acting to retard the exit of the steam, in addition to there being an eddying action of the particles of steam and gases. The escaping steam has, further, to entrain and drag along, or otherwise displace, the hot air and the gases of combustion. As the velocity of the steam is much greater than that of the ascending air (this latter having an ascending power of its own in virtue of its being at a higher temperature than the outer atmosphere), the steam has to impart some of its velocity to this air, and is thus itself retarded — which means more back pressure in the cylinders. Very often the nozzles are badly shaped and set, so that the steam expands to the size of the stack bore before reaching the latter, thus striking on the smoke arch and greatly impeding the exhaust. Bearing all this in mind, we should be inclined to say that the back pressure would be less if exhausting into the atmosphere direct. (*c*) If the pressure inside a certain vessel were the same as that of the atmosphere, it would support a column of mercury 30 inches high. (We take this as the average value, with temperature at 60° F., which gives a pressure of 14.7 pounds per square inch.) If, now, the pressure in the vessel be decreased, it will, of course, support a lesser weight, that is, a shorter column of mercury. When the pressure is reduced say 6 pounds, that is, down to 8.7 pounds, it will support a column of mercury $\frac{8.7}{.49}$, or $17\frac{3}{4}$ inches high, and we then say there are $30 - 17\frac{3}{4} = 12\frac{1}{4}$ inches of vacuum in the vessel. If the pressure drops to 2 pounds per square inch, it can support $\frac{2}{.49}$, or about 4 inches, and we say there are 26 inches of vacuum. If the mercury falls from 30 inches to 15 inches (a drop of 7.35 pounds in the pressure), we say there is 15 inches of vacuum. (*d*) If you have a friend who understands the line of work the invention deals with, and you regard him as reliable, consult him: if you have no such friend, communicate with some consulting engineer in that particular line.

***

(324) (*a*) What is the correct pronunciation of the word *automobiling*, in the sense of riding in a self-propelling carriage? (*b*) When a moving body suddenly changes the direction of its motion, as the piston of an engine, or a baseball struck with a bat, does the body come to rest? (*c*) Are the advertisers in "The Mechanic Arts Magazine" reliable firms? (*d*) Please give instructions for making a wood-turning lathe and a jig saw from an old sewing machine.

L. L. D., Steelton, Pa.

ANS.—(*a*) We have not heard the verb *to automobile*, nor its participle *automobiling*. If, however, we must bear the use of words so monstrous, we think the pronunciation of the verb should be the same as that of the noun—*aut'ō mō beel'*, the primary accent being on the last syllable. (This is the French pronunciation; there is no recognized English pronunciation.) (*b*) In the mathematical treatment of mechanical problems of this kind, the motion of the body is

supposed to be continuous; there is properly no stoppage, as this would be a break of continuity. It is true that the body ceases to move in one direction; but the instant at which this occurs coincides with the instant at which the body begins to move in the opposite direction. From the point of view of metaphysics, the question of the continuity of motion, and of continuity in general, is a difficult one, and we cannot discuss it in this magazine. (*c*) While we cannot guarantee their responsibility, we believe that the firms advertising in "The Mechanic Arts Magazine" are thoroughly reliable business houses. (*d*) We are unable to furnish this information. Perhaps some of our readers will assist us in this respect.

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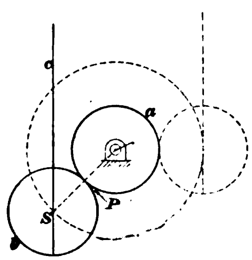
(325) "Tate's Philosophy," in describing the sun and planet wheels, says: "Assuming the two wheels to be equal, then, while the connecting-rod makes an up-and-down stroke, or, what is the same thing, while the planet wheel makes one revolution around the center of the system, the central wheel with the flywheel will have performed two revolutions; for in this case every tooth in the planet wheel will have come twice into contact with the teeth on the central wheel." Please explain, and give the principle involved, or, if this has already been explained in "The Mechanic Arts Magazine," in which number shall I look for it? L. C. P., Fort Fairfield, Me.

ANS.—To explain the principle of this motion by the principles of the epicyclic train would require more space than we can spare. The following explanation is much shorter and we believe fully as satisfactory. For simplicity, let us assume that the connecting-rod *c* (see figure) is very long, so that we may consider that it remains always parallel to any original position. Then, the rod *c* and wheel *b* has a motion of circular translation, and each point has the same velocity; thus, the point *P* has the same velocity as the point *S* at the center of the planet wheel. You understand, of course, that the planet wheel is rigidly fastened to the rod *c*. Now, the point *P* of the central wheel *a* must move with the same velocity as the point on the circumference of the planet wheel with which it is in contact. Hence, the points of the pitch circle of the central wheel have exactly the same velocity as all the points on the planet wheel, in particular the point *S*. Since, now, the points *P* and *S* have the same velocity, and *P* is traveling in a circle whose radius is one-half that in which the point *S* is traveling, it follows when *S* makes one revolution, *P*, to travel the same distance, in the same time, must go twice around its circle. In other words, the wheel *a* must make two turns while the planet wheel is making one revolution. The reasoning holds good when the connecting-rod is short, as in practice, except that the velocity of a point *P* on the pitch circle is equal to the *average velocity* of the center *S* of the planet wheel. Part of the time *S* is moving a little faster than *P*, and part of the time a little slower.



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(326) (*a*) How far does the mercury penetrate when amalgamating zincs are about ¼ inch thick? (*b*) At what temperature does crude petroleum freeze? H. N., Bayonne, N. J.

ANS.—(*a*) If the zincs are amalgamated by rubbing on the mercury until the surface is covered, and then rubbing off all the surplus mercury, the amalgamation will penetrate from $\frac{1}{32}$ to $\frac{1}{16}$ inch. If a zinc plate were allowed to rest, with a surplus of mercury on its surface, the mercury would, in time, work its way completely through the zinc. (*b*) It is impossible to give any definite temperature as the freezing point of petroleum, since the composition of crude oils varies so greatly. Some of these oils are very thick at ordinary temperatures, while others, again, are comparatively light. Asphalt, ozocerite, etc. are forms of petroleum that are solid at ordinary temperatures. The only safe way would be to determine the freezing point of any given sample by experiment, and it is doubtful, even then, if the exact freezing point could be determined, as most of these substances become very viscous at low temperatures, and it is difficult to tell at what temperature they pass from the semifluid state to the solid state.

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(327) (*a*) Knowing the altitude, how would you determine, approximately, the atmospheric pressure, say for an elevation of 6,500 feet? (*b*) How are the pistons of air compressors lubricated? (*c*) An old-time engineer claims that cylinder lubrication is utterly useless, and that the cylinders and pistons receive sufficient lubrication from the matter contained in the steam. He also claims that oil is not used in the cylinders while live steam acts upon the pistons, and that lubricators are only used when a locomotive runs down grade and live steam is turned off. Will you give me information on the subject? X. Y. Z., Minnehaha, Ariz.

ANS.—(*a*) The following is a common formula for finding the difference of elevation of two places:

$$H = 60{,}384.3\left(1 + \frac{t_1 + t_2 - 64}{900}\right)(\log h_1 - \log h_2),$$

in which H is the difference of elevation, in feet, and t_1 and h_1, t_2 and h_2, are temperatures (degrees Fahrenheit) and barometric readings (inches) at the lower and at the higher station, respectively. From this formula we get

$$\log h_2 = \log h_1 - \frac{H}{60{,}384.3\left(1 + \frac{t_1 + t_2 - 64}{900}\right)},$$

and from this the value of h_2 can be found, when h_1, H, t_1, and t_2 are known. Knowing h_2, the atmospheric pressure p, in pounds per square inch, is given approximately by the formula

$$p = 14.7 \times \frac{h_2}{29.9} = .4916\, h_2.$$

If pressures are taken at the standard temperature used for scientific purposes, that is, 32° F., then we have, at sea level, $h_1 = 29.9$ in., and, for an elevation of 6,500 feet, the formula gives

$$\log h_2 = \log 29.9 - \frac{6{,}500}{60{,}384.3} = 1.3680273;$$

whence, $h_2 = 23.34$ inches, and $p = 23.34 \times .4916 = 11.47$ pounds. (*b*) The air cylinders of a compressor are lubricated in much the same way—both as regards the kind of oil and the style of lubricator—as are the steam cylinders. (*c*) Cylinder lubrication, although desirable, is often very inefficient, which is perhaps what your informant means. Water does act as a lubricant to some extent, in that it gets in between the surfaces and keeps them apart—this being one of the functions of a lubricant, and a prompt carrying away of the heat generated being the other. Water has no body, however, and is a very poor lubricant, at best. As regards locomotive cylinders: undoubtedly in the past these have been getting no lubrication whatever, when running with full throttle and notched right up. In early days it was not attempted to lubricate them under those conditions, the oil being fed only when drifting—that is, running with steam shut off. Even now,

with the automatic lubricators in general use, the supply to the cylinders and steam chest is very inefficient under the conditions mentioned, if, in fact, any oil gets there at all. This difficulty has, however, been overcome by the Detroit Lubricator Co. by using a special attachment that, when the throttle is open, allows an auxiliary jet of live steam to pass into the oil pipe in front of the choke plug (i. e., between it and the steam chest), and so overcome the resistance due to pressure in the steam chest.

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(328) If a steam boiler is absolutely tight and contains a given quantity of water, and steam is raised to a pressure of 100 pounds without opening any valves, and the boiler is then allowed to cool down, would the quantity of water be diminished, and if so, where would it go? F. G. S., Postville, Iowa.

ANS.—If there were no leak in the boiler there would be no diminution in the quantity of water after steam had been raised and then allowed to cool down. Any steam that was formed would be condensed and returned to water again when the boiler was cooled down.

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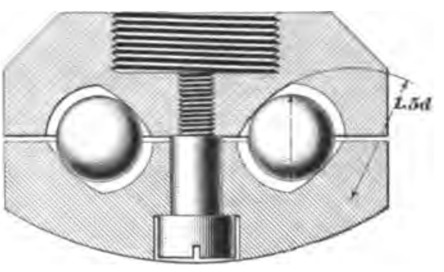
(329) Is there a formula that will help me in determining the diameter of a brass footstep bearing for a steel spindle that makes 4,000 revolutions a minute, against a total end pressure of 200 pounds? What is the best metal to use for the above bearing? H. A. L., Norwich, Conn.

ANS.—There is no formula that can help you, as, on account of the high speed, your case is an exceptional one, and formulas such as given in memorandum books, etc. are serviceable only for cases within limits of every-day practice. Giving the matter a little thought, you will see that an ordinary brass step cannot be made that will not, under the



conditions given, heat up beyond control in a few minutes. The loss by friction is expressed by the formula:

$$L = \frac{P \times f \times \pi \frac{d}{2} \times N}{12} \text{ ft.-lb. per min.,}$$

in which

d = diameter of step;
f = coefficient of friction = $\frac{1}{16}$ ($\pi \times f = \frac{1}{5}$, nearly);
P = 200 pounds;
N = 4,000 revolutions per minute.

Now, if you were to make the step 2 inches in diameter only (provided this would not make the pressure between the surfaces in contact too high, which it actually does), the frictional work would be

$$L = \frac{200 \times 1 \times 1 \times 4{,}000}{5 \times 12} = 13{,}333 \text{ ft.-lb.;}$$

this is equivalent to an amount of heat per minute that cannot be taken care of by ordinary means. We suggest that you try a ball bearing, as indicated in the accompanying sketch. The pressure being comparatively small, you can probably use few balls of large diameter. Just what dimensions to adopt we cannot advise, not knowing particulars as to side strains on the shaft, etc. Keeping the radius of the circle of ball centers down reduces frictional work, and increasing the diameter of the balls does likewise; hence, our suggestion of using few, but large, balls. The cups, as well as the balls, should be highly polished hardened steel.

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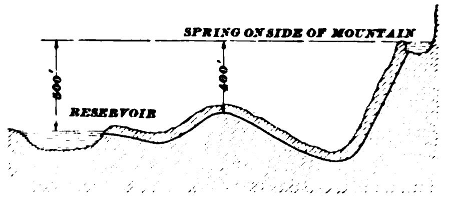
(330) What will be the flow of water at the outlet of a 12-inch pipe, with source of supply 500 feet above outlet, length of pipe 15 miles, running across country having profile something like that in enclosed sketch? Under the above conditions, would



the flow be the same as if the fall from source to outlet were continuous at the rate of 500 feet in 15 miles, and what would be the loss per hundred feet due to friction? W. P. T., Staunton, Va.

ANS.—The rate of flow will depend on the distance from the discharge end of the high point in the pipe line. If this point is not less than 3 miles from the discharge end of the pipe, and the slope from it to the end is moderately uniform, the flow will be the same as if the fall from the source to the outlet were uniform. Under these conditions, the flow from a new, smooth, cast-iron pipe will be about 3¼ cubic feet per second. If the pipe is old and rough, the flow may not be more than 70 per cent. of this, or 2¼ cubic feet per second. If the high point in the pipe line is less than 3 miles from the discharge end, the rate of flow will be somewhat less, the amount of the reduction being greater as the high point approaches the end of the pipe. The frictional losses depend on the length of the pipe, its diameter, the velocity of flow, and the condition of the inner surface of the pipe. There is no simple general expression for the relation between length of a pipe and the frictional losses. In the case of the pipe under consideration, practically all of the energy represented by the fall of the water from the spring to the reservoir at the discharge end is absorbed in overcoming the frictional resistances.

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(331) (*a*) Can a compound-wound dynamo of 100 amperes current capacity be overloaded temporarily to 160 amperes, when starting an electrically driven wagon? (*b*) What percentage can a compound- or a shunt-wound dynamo be overloaded, temporarily, in starting an electric wagon? (*c*) A Weston ammeter is used to measure the current furnished to a single car, and the current varies rapidly from 40 to nearly 200 amperes. Is this a true indication of the current, or are the indications due to the sudden swing of the needle? GRAND FORKS.

ANS.—(*a*) The amount by which a dynamo may be overloaded depends altogether on the design of the machine. Some makers rate their machines so high that very little margin is left for overloading, while others rate their machines liberally and they can stand considerable overloads, for short periods, without injury. A good machine, of which the normal output is 100 amperes, should carry 160 amperes for short intervals, provided the overload does not cause excessive sparking. It is always best to have ample capacity in the dynamo in order to avoid overloading as much as possible. (*b*) A good railway or power generator will stand overloads of from 50 to 75 per cent. for short intervals. Shunt

machines will not stand overloads as well as compound machines, for the reason that the heavy overload is liable to weaken the field, and thus cause sparking. (*c*) The indications of a Weston ammeter used for this work are practically correct. These instruments are very dead-beat and the moving parts are light and possess little inertia. The movements of the needle are therefore a correct indication of the variations in the current.

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(332) In the plant where I am employed there is a well 70 feet deep that furnishes water for a boiler. A common steam pump is used, but during dry weather the water in the well is so low that the pump is unable to raise it. (*a*) Can I get a well pump and let it down 60 feet into the well and connect its discharge to the suction of the pump on the surface? (*b*) If so, where can I get such a pump?

P. W. F., Canton, N. Y.

ANS.—(*a*) A well pump might be connected to the suction of the pump on the surface, as you suggest, but it would be difficult to make such an arrangement work satisfactorily. A better way would be to have the well pump discharge into a tank from which the feed-pump could draw its supply. (*b*) Write to the Baldwinsville Centrifugal Pump Works, Syracuse, N. Y., or the Goulds Manufacturing Company, Seneca Falls, N. Y.

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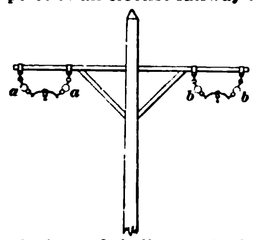
(333) The enclosed sketch is an attempt to represent the method of fastening the trolley wire to the poles of an electric railway that is being constructed in this section. The parts *a* and *b* are said to be a composition of mica and some other material, and are about 1¼ inches in diameter. Can you explain this? Is it an improved method, and what are its advantages?



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ANS.—The balls *a*, *a*, *b*, *b* are insulators, the body being composed of mica and shellac, or similar material. The method of trolley-wire suspension, indicated in the figure, is a modification of the flexible-bracket suspension, and its advantage lies in the smoothness with which the trolley passes the point of support, avoiding a sudden blow that may cause the wheel to break contact with the wire.

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(334) (*a*) How many square inches of sheet iron will 5 cubic feet of natural gas heat from 70° to 450° F., and keep at that temperature for 1 hour, when consumed so as to produce a blue flame? (*b*) On my property there is a spring through which natural gas bubbles at the rate of about 250 cubic feet every 24 hours. I purpose collecting this gas and using it to heat a shaking pan for drying rolled oats, rolled wheat, etc. as they pass over the shaking pan. What must the pressure of the gas be to give satisfactory results?

W. S. G., Greenwood, Ont.

ANS.—(*a*) There are so many conditions to be considered in connection with this question that it is impossible to give an answer that will be anything more than a guess. The heat required for a given area of the sheet iron depends on the thickness of the iron, on the area of the iron exposed to the cooling effects of surrounding objects, on whether the iron is enclosed so as to prevent loss of heat or whether it is exposed to currents of air, and on many other conditions that you have not stated. Five cubic feet of natural gas has a theoretical heating value equal to about ½ pound of good coal; this fact may enable you to make an estimate as to whether or not you can profitably use your gas supply. (*b*) The best pressure to use depends somewhat on the type of burner used. With a burner of the Bunsen type, or any burner in which the gas and air are mixed, a pressure at the burner corresponding to a water column 1 inch high will give very good results.

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(335) Please explain the method of starting the gasoline engine illustrated in "Home Study Magazine," January, 1899, page 554. Is it necessary to heat the plate to generate gas before starting?

E. H., Akron, Ohio.

ANS.—The engine is started by turning the shaft *S* in the direction the engine is to run; this operation draws enough air and gasoline vapor into the cylinder, after a few turns have been made, to form an explosive mixture that will be ignited by the igniting spark, and start the engine. It is not necessary to heat the plate to generate gas to start the engine; enough gasoline will be vaporized at ordinary temperatures to form an explosive mixture with the air drawn in through the plate.

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(336) (*a*) In a certain table, the values of 1, .5, and .25 are given as the relative heat-insulating values of different materials. Will 2 inches of a substance marked .5, or 4 inches of another marked .25, be as efficient as 1 inch of that marked 1? (*b*) If a 150-horsepower automatic engine, cut-off at ¼ stroke, is required to give only 75 horsepower, will the cut-off take place too early to give the best economy? (*c*) Would it be more advisable to reduce the speed or the cut-off?

A. N., Toronto, Can.

ANS.—(*a*) The relative values are probably based on experiments showing the relative quantities of heat transmitted by equal thicknesses of the different materials; it is, therefore, not certain that the heat transmission is inversely proportional to the thickness. Probably, however, such proportions as you suggest would give nearly equal insulating values. (*b*) Yes. (*c*) Since a reduction of the cut-off, which is quite early already, will result in a loss in economy due to increased range of temperature and consequent condensation, we would be in favor of reducing the boiler pressure. Then there will be no changes required in the countershafts and belting, and all things considered, the economy will be better than it would be if the speed is lowered.

***

(337) Will you inform me where I can get the constructive drawings of the "Cup Defender" Columbia, so that I could make a model of same?

W. H. S., Philadelphia, Pa.

ANS.—We do not think that it is possible for you to secure these drawings. You might, however, address Herreshoffs, the builders.

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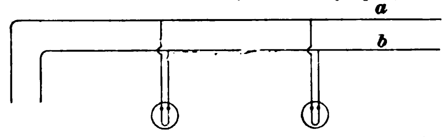
(338) (*a*) Are the ends of the main wires of an incandescent circuit closed, or are they open, as in



the enclosed sketch? (*b*) Kindly show, by drawing a simple plan, how to wire four adjoining rooms for incandescent lighting.

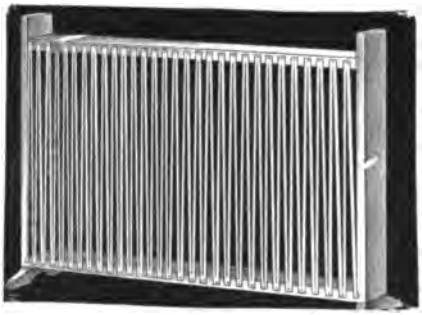
C. H. B., New Richmond, Ohio.

ANS.—(*a*) If the ends of the wires *a*, *b* of the sketch were connected, there would be a short circuit. (*b*) Many different plans can be used, and to sketch them, to take in all cases, would take too much space. There is no general plan that can be recommended without being acquainted with the space to be wired. Get "Badt's Incandescent Wiring Handbook," which can be had for $1.00, from The Technical Supply Company, Scranton, Pa.

(339) Please tell me how to construct a dimmer used on circuits of from 100 to 125 volts and to control anywhere from 10 to 75 lamps. I want something on the style of a rheostat.

W. S. H., South Weymouth, Mass.

ANS.—Construct a wooden frame from 1-inch stuff, 3 or 4 inches wide. The end uprights, as shown in the figure, are 30 inches long, and the horizontal pieces, included between them, are each about 42



inches long. The whole is supported by suitable foot-pieces. Two sheets of roofing tin are then procured, each sheet being 20 inches wide by 28 inches long. With a lead pencil, mark off lengthwise on the sheet 61 strips, $\frac{5}{16}$ inch wide. Now, cut the tin along the first line until about an inch from the end; then, from the same end, cut along the second line until an inch from the opposite line. Continue in like manner to cut along the lines until the whole sheet is done, when the strips, slightly parted, will present the appearance shown in the sketch. Both sheets being prepared in the same manner, one is fastened to one side of the frame with tacks, as shown, and the other is nailed to the other side, but for the sake of clearness the latter is not shown in the illustration. Terminals may be used, or a sliding shoe, such as is shown near the left-hand end, may be employed. The latter method of control may be resorted to when the two sides of the rheostat are connected in multiple. The cold resistance is about 7½ ohms. As the current increases the resistance increases, on account of the heating of the strips, so that at 10 amperes, the resistance is about 8 ohms; at 20 amperes, 14 ohms; at 25 amperes, 18 ohms; and at 30 amperes, the tin becomes so hot that the frame smokes, thereby limiting its capacity.

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(340) (*a*) Please publish full details of construction of a storage cell, including prices of materials. (*b*) Can a storage battery be charged from the following circuits: 550-volt trolley; 110-volt; 52-volt?

THE X Y Z CLUB, Kingston, Jamaica, B. W. I.

ANS.—(*a* and *b*) This question cannot be adequately answered in these columns, as space does not permit giving all the details necessary for a complete answer. We would refer you to the book entitled, "The Storage Battery," by Treadwell, for complete information on this subject.

***

(341) Will you kindly explain the method of calculating the cost of electrical power from the meter reading, taking the following case as an example? The power company charges \$7.00 per horsepower per month. With a bill of \$253.40, the meter reading was 3,376, dial farthest to the right reading hundreds; meter constant, 20.

A. W. C., Portland, Ore.

ANS.—The meter constant being 20, the number of watt-hours will equal $337{,}600 \times 20 = 6{,}752{,}000$. As 1 horsepower equals 746 watts, the work done will be $6{,}752{,}000 \div 746 = 9{,}051$ horsepower-hours. Allowing 25 days as constituting a working month, each day being taken as of 10 hours length, the number of working hours per month will be 250. The number of horsepowers per month to equal 9,051 for 1 hour will be $9{,}051 \div 250 = 36.2$, which, charged for at the rate of \$7.00 per horsepower per month, will cost $36.2 \times 7 = \$253.40$.

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(342) (*a*) What is the depolarizer in the Taylor cell? (*b*) What should be the strength of the perchloride-of-iron solution in the Pabst cell? (*c*) What kind of cement can I use for sealing porous cups?

M. S., Santa Barbara, Cal.

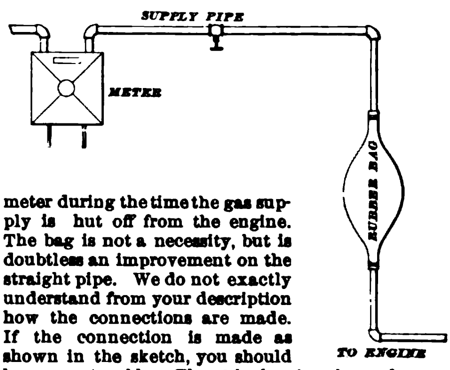
ANS.—(*a*) This is a type of cell with which we are not familiar, and which is not described in the standard works on batteries. If you could give us more detailed information regarding its construction, we might be able to tell something about the action of the battery. (*b*) Use a saturated solution. (*c*) Mix equal parts of rosin and paraffin and heat together for several hours.

***

(343) We are manufacturers of water gas, and are trying to run a 1-horsepower gas engine in one of our departments. The engine was formerly run with gasoline, but was changed to use gas. There is a rubber bag attached to, and hanging from, the supply pipe, connection being made by means of a ¾-inch pipe. At the connection, the supply pipe is 1 inch, but is immediately reduced to ¾ inch; the distance from the mouth of the rubber bag to the engine inlet is 4 feet. The main supply pipe, leading to the pipe from which the bag is pendent, is 1¼ inches. The engine will start all right, but as soon as the gas in the rubber bag is exhausted it stops and acts as though it did not have a sufficient supply of gas. Of what use is the rubber bag? Is it a necessity? How should the connections be made so as to prevent the above trouble?

B. A. B., Clyde, Ohio.

ANS.—The rubber bag acts as a reservoir, keeping a supply of gas close at hand. The charge taken from the bag is replaced by a gradual flow through the



meter during the time the gas supply is hut off from the engine. The bag is not a necessity, but is doubtless an improvement on the straight pipe. We do not exactly understand from your description how the connections are made. If the connection is made as shown in the sketch, you should have no trouble. The ¾-inch pipe is perhaps a little small.

***

(344) Does it require a 1,000-horsepower boiler to supply steam for a 1,000-horsepower engine?

R. B., Newport, R. I.

ANS.—The size of boiler required for an engine of a given power depends on the type of the engine. A 1,000-horsepower triple-expansion condensing engine running under the most favorable conditions might be readily run with a 500-horsepower boiler; on the other hand, the engine might be run under such unfavorable conditions that a 1,000-horsepower boiler could not supply it with steam.

(345) In the June number of "The Mechanic Arts Magazine," one of the good schemes that attracted my attention told of planing short keyways. I have some work that has to be done on planer centers, and all that I have for my tool to stop in is ¼ inch. We have a Pratt & Whitney planer, which shows unevenness of back stroke of as much as 3 inches, while on the forward stroke it is all right. Is it a common thing with most planers to show variation of back stroke, or is this particular planer at fault? If so, how can I remedy the defect?

J. G. F., Rockville, Conn.

ANS.—The fact that the planer works correctly on the forward stroke ought to show you that the trouble you experience is not inherent with all planers. Probably you have a bad belt on the return pulley, patched or pieced, so that it presents different resistances to being shifted at different times. Conducive to accurate and prompt action of the reversing mechanism of a planer are narrow belts and high speeds.

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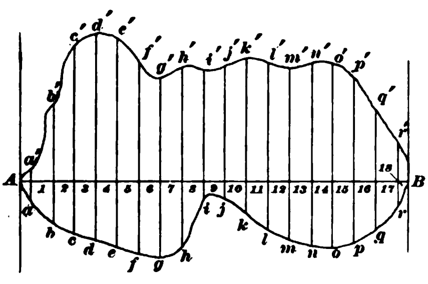
(346) (*a*) If heat is applied to a boiler that has previously been pumped full of water, is it possible for the gauge to show 80 pounds of steam? (*b*) Given, a boiler half full of water, and the gauge showing 80 pounds of steam, is it possible to pump the boiler full? (*c*) Why is it that when you turn a thermometer upside down the mercury does not change



ends? (*d*) Explain a simple method by which the area of the figure of the enclosed sketch can be calculated with a fair degree of accuracy without using the planimeter. T. B. Z., De Soto, Ill.

ANS.—(*a*) Since the boiler is completely filled up, steam cannot be formed. A pressure of 80 pounds on the gauge would then indicate the pressure of the hot water in the boiler. (*b*) Yes, if sufficient pressure is applied. The steam will then all condense. (*c*) The bore of the thermometer is very small, and the adhesion between the mercury and the glass is sufficient to prevent the former from dropping downward when the thermometer is turned upside down. (*d*) Draw a line *A-B* between the extreme points *A* and *B* of the irregular figure. Divide this line into a number of equal parts *A-1*, *1-2*, *2-3*, etc. At the middle point of each of these equal divisions, erect the perpendiculars *a-a′*, *b-b′*, etc. Measure the length of each of these perpendiculars and add their individual lengths together. Divide the sum thus obtained by the number of perpendiculars, and multiply the quotient by the length of *A-B*. The result will be the area of the figure. Thus, we divided *A-B* into 18 equal parts, and, consequently, we erected 18 perpendiculars. The sum of these 18 perpendiculars ($a\text{-}a' + b\text{-}b' + c\text{-}c' + \ldots + p\text{-}p' + q\text{-}q' + r\text{-}r'$) we found to be equal to 32 inches. Dividing this sum by the number of perpendiculars, we have $\frac{32}{18} = 1.78$ inches. Multiplying 1.78 by the length of *A-B*, which is 4.5 inches, we have $1.78 \times 4.5 = 8.01$ square inches, as the area of the figure. The greater the number of equal parts into which *A-B* is divided, the greater will be the accuracy of the result.

(347) How was absolute zero determined?

K. C., New York, N. Y.

ANS.—If a tube is filled with air at 32° F. and has a volume v, and if the temperature is changed while the pressure remains constant, then experiment shows that, for every degree F. that the temperature is raised or lowered, the volume of the air increases or decreases, as the case may be, by an amount equal to $.0020361v$. The volume v_t of the air at $t°$ F. is, therefore,

$$v_t = v[1 + (t - 32) \times .0020361].$$

If this formula held true for all temperatures, however low, we would obtain the absolute zero of the air thermometer by making $v_t = 0$. This gives

$$1 + (t - 32) \times .0020361 = 0;$$

whence,

$$t = -\frac{1}{.0020361} + 32 = -459.13°.$$

Furthermore, if air were a perfect gas, the absolute zero of the air thermometer would be the absolute zero of temperature. As, however, air is not a perfect gas, though very nearly so, a correction is necessary. The equation of a perfect gas is

$$p\,v = R\,t_a,$$

in which p = pressure in pounds per square foot;
v = volume in cubic feet;
t_a = absolute temperature;
R = constant (= 53.30, nearly).

It is shown in thermodynamics that, if the pressures of a perfect gas at temperatures t_1 and t_2 of the air thermometer are p_1 and p_2, and T is any absolute temperature to which there corresponds a temperature t of the air thermometer, then

$$T = t + \frac{H\,(t_1 - t_2)}{R\,(\log_e p_1 - \log_e p_2)},$$

in which H = specific heat of the gas at constant pressure. By means of this formula, the data for the application of which have been determined by experiment, the absolute zero has been found to be −460.7° F.

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(348) What are the best books on mechanical movements, electric motors, hydraulics, and hydraulic machinery? I want a book on electric motors that tells all about the wiring and gives the names and purposes of all the parts in detail. The books must be in the simplest possible language.

J. F. W., Philadelphia, Pa.

ANS.—The following books on the subjects you mention can be recommended: "Mechanical Movements, Devices, and Appliances," by Hiscox, price $3.00; "Practical Managemen of Dynamos and Motors," Crocker and Wheeler, price $1.00; "A Treatise on Hydraulics," by Mansfield Merriman, price $4.00; "Pumping Machinery," by William Barr, price $5.00. Any of these books may be obtained from The Technical Supply Company, Scranton, Pa.

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(349) I have a 16-horsepower traction engine: the pump, which is of the crosshead type, seems to have plenty of suction, but it will not keep up the water while we are thrashing; it does all right on light work or when moving on the road. The enclosed sketch will explain the arrangement of piping, etc. (*a*) Where does the trouble lie? (*b*) Does the vacuum chamber in the suction pipe do any good?

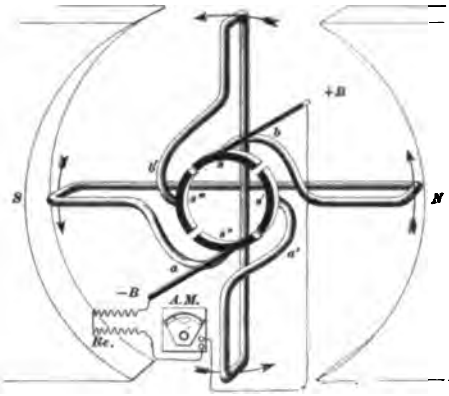
F. S., Logan, Ill.

ANS.—(*a*) There seems to be nothing abnormal in the arrangement, as shown in your sketch. The trouble lies, probably, in leaky valves. (*b*) Yes; it assists the pump, especially at high speeds. When the suction valve closes, the water in the suction pipe continuing its motion by reason of its inertia, compresses the air in the chamber and is gradually brought to rest, instead of suddenly. Thus shocks and consequent strains on the piping are avoided.

(350) (*a*) Can you tell me how to wind a four-section armature, and how to connect the wires from the armature to the commutator? (*b*) What size of wire would be best for the armature?

E. I., Georgeville, Minn.

ANS.—(*a*) You may connect the terminals of the two coils to the four commutator segments, as shown



in the figure. We take it for granted that the armature has two coils, each coil filling up two sections. In the figure, each coil is shown consisting of one loop only, in order to obtain clearness. Each coil might consist of several turns, the terminals of the coils being connected to the segments, as shown. (*b*) Your information is not sufficient for us to give any reply as to the size of wire to be used. The size of wire will depend on the current that you wish to take from the machine.

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(351) (*a*) What is the resistance of a 16-candlepower lamp at 75 volts, at 100 volts, at 110 volts, and at 220 volts? (*b*) If five 16-candlepower 100-volt lamps are put in series on a 500-volt circuit, what is the current per lamp, and what is the current of the circuit? (*c*) If a small shunt-wound dynamo for 80 volts is connected in series with five 16-candlepower 100-volt lamps, what amount of current will flow to the dynamo if the voltage of the circuit is 500 volts? The armature is wound with No. 21 B. & S., the field with No. 34 B. & S.; the armature convolutions equal 280 and about 320 feet.

E. J. W., Yarmouth, N. S.

ANS.—(*a*) Voltage of circuit 75: efficiency of lamp, 3.5 watts per candlepower; resistance equals, approximately, 100 ohms. Voltage 100: efficiency, 3.1 watts; resistance, 200 ohms. Voltage 110: efficiency, 3.1 watts; resistance, 244 ohms. Voltage 220: efficiency, 3 watts; resistance, 1,000 ohms. (*b*) The current in the circuit, and consequently that in each lamp, will be $\frac{1}{2}$ ampere. (*c*) Connect the field in series with four 16-candlepower 110-volt lamps, independently of the armature. For the armature circuit, make up four banks of lamps with the requisite number in parallel in each bank, and connect all in series with one another and with the armature. It is impossible to state the amount of current that will be taken, from the meager data you have given, but it will certainly not be over .6 ampere.

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(352) Please tell me the difference between the enclosed and the open types of arc lamps.

C. A. B., Brownstown, Ind.

ANS.—An enclosed-arc lamp is one in which the arc is enclosed in a chamber from which nearly all the air is excluded. This is done to prevent the rapid consumption of carbons that takes place when the highly heated carbons are exposed to the atmosphere. A lamp of this construction differs from the ordinary open type in that the current consumption is smaller, though the drop of potential across the arc is higher (for the same candlepower). The washer through which the upper carbon passes is so designed that a small amount of air is allowed to enter the chamber enclosing the arc, for the reason that it is desirable to prevent the deposition of carbon vapor on the inside of the globe. The amount of air entering in this manner is not enough to materially affect the life of the carbons, as the greater part of the loss is due to the volatilization of the carbons, caused by the intense heat of the arc. As before mentioned, the carbon vapor is oxidized by the air that is allowed to enter. The advantage of this style of construction lies in the fact that one pair of carbons will last from 100 to 200 hours, instead of from 7 to 10 hours, as in the open lamp. Both are made for alternating- and direct-current circuits of all commercial voltages.

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(353) (*a*) Can you give me the composition of phosphor-bronze gear? (*b*) Have you a course in The International Correspondence Schools that covers brass-foundry work? H. S., Boardman, S. C.

ANS.—(*a*) Phosphor bronze is generally composed of 10 parts of tin, 9.5 parts of lead, 79.7 parts of copper, and .8 part of phosphorus; we do not know the exact composition of bronze used for gear. (*b*) No.

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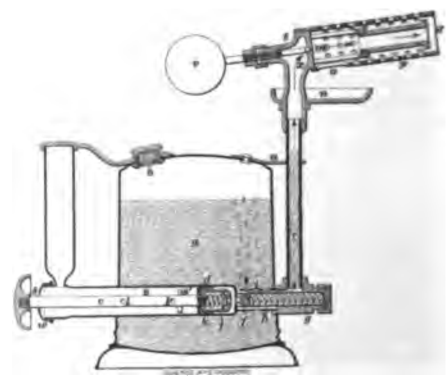
(354) (*a*) Please show, by sketch and explanation, how gas is formed from gasoline in a blow torch. (*b*) What is the object of pumping the gasoline tank full of air? (*c*) What book gives instructions on brazing?

L. S., Dallas, Ore.

ANS.—(*a*) The accompanying figure illustrates a gasoline torch of common form. The gasoline in the blow-torch chamber *a* is forced up through the tube *r* to the burner by the air under pressure in the space *b*. This pressure is secured by means of an air pump of which *e* is the cylinder and *c* the piston rod. The liquid gasoline flows out through the needle valve at *m* and falls into a cup *n*, where it is ignited and the flames from the cup envelop the burner and heat it. This vaporizes the gasoline in the space *x*, so that when the burner is heated and the needle valve is opened, vapor flows from *m* and is ignited inside the burner. The heat from this flame keeps the burner hot enough to vaporize the liquid before it



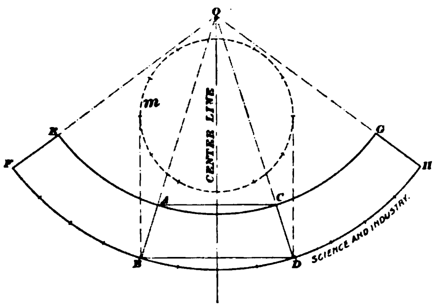
reaches the aperture of the needle valve. The best form of burners are those in which the gasoline must pass through a channel or small tube that is in constant contact with the torch flame. (*b*) The object of pumping air into the gasoline tank is simply to force the liquid gasoline up to the burner. If the gasoline chamber were higher than the burner,

the liquid would flow by gravity to the burner and, therefore, would not require air pressure. (*c*) You will find some instructions on brazing in the following books: "The Art of Coppersmithing," by John Fuller, price \$3.00; "Bicycle Repairing," by S. D. V. Burr, price \$1.00: "Manual of Instruction in Hard Soldering," by Harvey Rowell, price 75 cents. Any of these books may be obtained from The Technical Supply Company, Scranton, Pa.

* * *

(355) (*a*) How would you cut a lining to fit exactly the curved surface of the frustum of a cone whose slant height is 2½ inches, small diameter 5¾ inches, and large diameter 7½ inches? (*b*) Please tell me how to cut a hole for an 8-inch pipe to pass horizontally through a roof whose pitch is 10 inches in 1 foot. F. F. H., Norway Mines, N. S.

ANS.—(*a*) First draw a view of the frustum in the given dimensions, as *A B C D*; describe the circle *m* to represent a view of the lower base. Draw the center line and produce the sides *A B* and *C D*



until they meet in the point *O*. With *O* as a center, and with radii *O A* and *O B*, describe, respectively, arcs *E A C G* and *F B D H*. Divide circle *m* into a convenient number of equal parts (twelve in the figure), and space off an equal number of similar parts on the arc *F B D H*; draw *H O* and *F O*. The figure *E A C G H D B F* is thus produced, which is the pattern for the required lining of the frustum. (*b*) The opening is in the shape of an ellipse whose minor axis is 8 inches (the diameter of the pipe), and whose major axis is 12½ inches. The length of the major axis in such problems is most easily found by means of the graphic method; that is, draw parallel lines 8 inches (or the diameter of the pipe) apart and intersect them with a secant whose angle of inclination shall equal that of the roof line. The length of the major axis, then, is that part of the secant included between the parallel lines. Or, it may be found by proportion and the right-angled triangle, as follows: $10:12::8:9.6$, then major axis $= \sqrt{8^2 + 9.6^2} = 12.5$, nearly.

* * *

(356) (*a*) A line of hose, say 50 feet long and 2 inches in diameter, is connected to a hydrant furnishing water under a pressure of 80 pounds per square inch. When used without a nozzle, the range of the stream is measured; after this a nozzle ¾ inch in diameter is attached to the hose. In which case will the range be greater, and why? (*b*) A ball 12 inches in diameter is placed in a box so as to touch the bottom and two sides. What is the diameter of the largest ball that can be placed behind the large ball, so as to touch it, two sides of the box, and the bottom? Please explain fully, showing work. W. H. G., Gaffney, S. C.

ANS.—(*a*) The range will be greater but the quantity of water discharged will be less when the nozzle is used. Stated very briefly, the reason for the increased range is that when the velocity of flow through the hose is low, as is the case when the nozzle is used, a smaller proportion of the energy of the water is absorbed in overcoming frictional resistances. When water flows through a pipe, the energy absorbed in overcoming frictional resistances is nearly proportional to the *square* of the velocity of flow. (*b*) Let r denote the radius of the small ball. Then, the three edges of the box are a system of coordinate axes, the coordinates of the center of the large ball are 6, 6, 6, and the coordinates of the center of the small ball are r, r, r. Therefore, the square of the distance between the centers of the balls is

$$(6 - r)^2 + (6 - r)^2 + (6 - r)^2 = 3(6 - r)^2.$$

But the distance between the centers is $6 + r$. Hence, we have

$$3(6 - r)^2 = (6 + r)^2.$$

Solving this equation, we get

$$r = 6(2 \mp \sqrt{3}).$$

Thus, the radius of the small ball is

$$6(2 - \sqrt{3});$$

and $$6(2 + \sqrt{3})$$

is the radius of a ball that touches the 12-inch ball on the opposite side from the corner of the box, and also touches the sides of the box.

* * *

(357) Kindly tell me the derivative of the decimals used in the standard multipliers, viz., 3.1416, .7854, .31831, .5236, their root or what they are evolved from, why they are standard, and why we use them. E. T. P., Buffalo, N. Y.

ANS.—It can be proved geometrically that the circumference of a circle is approximately equal to 3.1416 times the diameter; hence, 3.1416 is a very important number in the mensuration of the circle. The other numbers are obtained from 3.1416, thus: $.7854 = 3.1416 \div 4$; $.31831 = 1 \div 3.1416$; and $.5236 = 3.1416 \div 6$.

* * *

(358) (*a*) Can the steam loop be used in the two-pipe system of heating, and where do you connect your pipes to separator? (*b*) Give rule for finding height of loop from water level of boiler. G. D., Jackson, Tenn.

ANS.—(*a* and *b*) We would advise you to submit these questions to Messrs. Westinghouse, Church, Kerr & Co., New York, who control the patents on the steam loop and who can give you any information about its use that you may require.

* * *

(359) (*a*) Please tell me how to prepare and to wipe a lead joint. (*b*) Would there be any saving in fuel in changing a low-pressure circulating steam-heating plant to one of high pressure with the addition of a reducing valve? (*c*) If so, what changes would have to be made? J. E. K., Milford, Neb.

ANS.—(*a*) The process of preparing and wiping a joint on lead pipes is altogether too long to be fully described here, but we take pleasure in recommending to your notice "The Art of Joint Wiping," the first part of which was published in the October, 1899, number of "The Building Trades Magazine," and the second part in the November, 1899, number of SCIENCE AND INDUSTRY, of which "The Building Trades Magazine" is now a part. This article clearly describes the process, from the cutting of the pipe to the finishing of the wiping. It is illustrated with 10 photographs, which, one after the other, show the process from the beginning to the end. (*b*) No; there would be no saving unless more particular attention was given to the firing under the high pressure than under the low pressure. (*c*) We cannot tell what changes would have to be made unless we could personally examine the plant. We would assume, however, that if the boiler and radiators are strong enough, and the piping properly proportioned, there will be no changes required to run under a pressure of 10 pounds. If you can

possibly run low pressure and heat the building, we would advise you not to make a change, for best results are obtained from low-pressure systems.

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(360) (*a*) What is the composition used in making a draftsman's duplicating pad? (*b*) How are ordinary rubber stamps made?

F. A. W., Jacksonville, Fla.

ANS.—(*a*) We suppose you refer to what is known as the hectograph, for which we append two recipes:

(I)

Gelatine	100 parts
Water	375 parts
Glycerine	375 parts
Kaolin	50 parts

(II)

Glue	100 parts
Glycerine	500 parts
Finely powdered kaolin or baric sulphate	25 parts
Water	375 parts

(*b*) For want of space, we cannot attempt to detail the process of this branch of manufacture. As regards the material of the stamp itself, it is a pure unvulcanized rubber, prepared in a special way for vulcanization.

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(361) Please answer the following questions in the inquiry columns of your magazine: (*a*) Give a list of the names of the different kinds of arches employed in building construction. (*b*) Show how the joint lines of elliptical and parabolic arches are obtained. (*c*) Explain how the working patterns for a circular stone arch in a circular wall are laid out.

C. M., Brooklyn, N. Y.

ANS.—(*a* and *b*) For the names of different kinds of arches, and methods of obtaining the joint lines for same, we would refer you to "The Building Trades Pocketbook," which is published by The Colliery Engineer Company. Interesting information in regard to elliptical and Gothic arches is given in the November, 1898, issue of "Home Study for the Building Trades." (*c*) This question is completely answered in "Home Study" for the month of August, 1896, which may be had for 15 cents, by addressing The Colliery Engineer Company, Scranton, Pa.

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(362) Can you describe a practical system of marking iron structures, especially iron stairways? What I want is a system easy to understand and that can be remembered without drawings or notebooks—it being understood between the shop and the erector that a certain number or letter designates a certain location.

C. T., Cleveland, Ohio.

ANS.—As you suggest in your inquiry, it is customary to employ the cumbersome system of piece numbering in the erection of iron structures; that is, each piece or detail is numbered on the drawing, and corresponding numbers are placed on the pieces in the shop, and the erector must possess the drawing in order to locate the piece required. Such a method is absolutely necessary in dealing with complicated structures, and, as in the erection of such structures the man in the field must necessarily have drawings to go by, there is not much difficulty encountered. In ordinary work a good method to employ would be to divide the building into four sections by two axial lines. Thus, there would be the right and left front, and the right and left rear, which could be designated by *R F*, *L F*, *R R*, and *L R*, respectively. The floor could be designated by numbers, *1* designating the space between the first floor and basement floor, while *2* would indicate the space between the second and the first floor, etc. The particular place occupied by the detail in the structure could be designated by numerals placed at or near the point of connection, the same numerals being in juxtaposition upon the piece connected and the connecting piece. For instance, assume that there is a cast-iron newel to be secured to the string of an iron stairway, and that is marked *3 R F* on the body of the casting and *3* at the bolt holes for the connection; the erector would know at a glance that the piece in question is to be located on the second floor in the front of the building to the right, and that it connects with the string on which the newel connection is marked *3*.

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(363) Will you inform me how lime is burnt, and how long it will take to burn a kiln?

P. B. T., Grangeville, Idaho.

ANS.—Lime, quicklime, or caustic lime is produced by burning, or calcining, limestone. The kiln is usually circular in cross-section, and ovoid, or resembling a truncated cone, in elevation. The limestone is fed at the top with alternate layers of fuel, and as the calcining process is completed, the lime product is taken out at the bottom. Such kilns are perpetual in their operation. Lime burners have found that the quantity of fuel expended and the quantity of stone calcined depend on the quality of the fuel used. It generally takes about 60 hours to calcine limestone when the heat is strong and well regulated, though the time required varies with the character of the stone.

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(364) I am interested in a flour mill, which I wish to heat with exhaust steam the coming winter. Can you give me information as to the points to be observed and the means to be employed?

G. H. W., Arden, Manitoba, Can.

ANS.—It is impossible for us to tell you the best way to heat your mill without a personal investigation of the premises. But it would appear to us that the most simple plan is to install a fan-blower system, in which the steam heating is accomplished under a very low pressure. The apparatus necessarily required for such a plant is a fan to blow air through the building, or a fan to draw air from the building; a large indirect heating stack through which the air may flow and become hot before it enters the building; a series of flues to distribute the air to the several parts of the building; a series of vent flues to take the foul air from the building and deliver it to the outer atmosphere; a large pipe connection from the exhaust pipe of the engine to the heater, to supply the heater with exhaust steam; a back-pressure valve on this pipe to allow exhaust steam to escape to the atmosphere should the pressure in the heater rise above 1 pound by the gauge; a pipe connection between the heater and the live-steam main, having a pressure-reducing valve attached that will furnish low-pressure live steam automatically to the heater, should the exhaust from the engine be insufficient at any time to supply the demands of the heater, or when the engine is not in use; a check-valve to prevent back pressure from getting on the engine, should the pressure regulator get out of order; means for removing grease and entrained water from the exhaust steam before it enters the heater; means for removing water of condensation from the heater and pumping it back to the boiler if necessary; and other minor details that depend on the conditions of the case.

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(365) Given, the sides of a triangle, how can the radius of the inscribed circle be determined geometrically?

L. F. B., Vergennes, Vt.

ANS.—Having drawn the triangle with the given sides, draw the bisectors of any two of its angles. The point of intersection of these bisectors is the

center of the inscribed circle, and the perpendicular from the center to any of the three sides of the triangle is the required radius.

***

(366) (*a*) Please describe a suitable contrivance for heating water in a fire-engine boiler while it is standing in the engine house. The boiler will contain about 20 gallons of water. About how much gas would be consumed in keeping this water at boiling point? Sometimes the steamer is not used for two weeks. (*b*) State why health boards will allow us to connect wash trays into the inlet side of the sink trap without trapping the tubs, and yet will not allow us to connect sink into wash-tray traps. H. S. W., Bayonne, N. J.

ANS.—(*a*) If your fire-engine is built like most of the best engines in the country, you will find that it has two ¾-inch brass pipes attached to the boiler and extending to the rear end of the engine where they join together, with a couple of blow-off cocks and open ends. One pipe connects to the side of the boiler about 3 inches below the working water-line, and the other connects to the bottom of the boiler. They may be used for surface blow-off or bottom blow-off if desired, but these pipes are really intended for connecting the steamer temporarily to a heater of some description for the purpose of keeping the water warm while the engine is in the house. The simplest plan, and, perhaps, the best, for warming the water as you desire it, is to construct a little brass ball, or other casting at the base of the pipe that rises and connects to the side of the boiler. Then rig up a Bunsen burner that comes up through the floor to the proper height for the flame to play upon the casting when the engine is in place. The water heated in this casting will rise in the pipe and discharge into the top of the boiler, and colder water from the bottom of the boiler will circulate through the pipe and into the casting to take the place of that which is heated. In this way you will have a good circulation and heat the boiler, and you can easily run the steamer out without having to unscrew any couplings or shut any valves. The amount of gas required would be from 5 to 10 cubic feet per hour. Of course, you can close the mouth of the smoke pipe to keep in the heat. (*b*) Because the waste pipe from the sink is always more foul than the waste pipe from the wash tubs, and it is very objectionable to have a long piece of foul pipe with an open end to the room, as would be the case if a sink discharged into a laundry-tub trap.

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(367) I have a tank for generating acetylene gas, which I use in magic lanterns. The tank is 2 feet high, 10 inches in diameter, and furnished with a floating cover. I fill the tank about one-third full with water, which covers a coil of pipe through which the gas passes to the burner. The carbide container is attached to the floating cover and arranged in such a manner as to lower in the water when the gas pressure falls, or to rise out of the water when the pressure is increased within the tank. The gas passes through several layers of gauze-wire netting before entering the outlet pipe. The acetylene burns with a bright light at the house burners, but gives off considerable smoke. Please tell me what is the matter.
A. M., Central City, Colo.

ANS.—Acetylene gas, like other gases of the hydrocarbon class, gives off smoke when too rich in carbon, and the cure is a supply of air to the burner, which mixes with the rich gas and dilutes it to the point most suitable for combustion. If you give rich gas too much air you decrease the luminosity of the flame; in fact, you can make a Bunsen flame by introducing more air than is required. There are special burners on the market for burning acetylene gas, and we would advise you to use them. If you already have acetylene burners, see that the air passages are not clogged up, and, if possible, open them out a little. Try, also, different pressures on the machine. If your pressure is too low, you can easily load the cover, which will increase the pressure. Properly constructed acetylene burners are supposed to operate successfully under ordinary pressures.

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(368) Will you give me any data you may know of in regard to the natural slope of earthy materials?
J. C. M., Philadelphia, Pa.

ANS.—As near as can be ascertained, the natural slope of earths with the horizontal is as follows:

Earth.	Slope. Degrees.
Moist sand	22
Dry sand	38
Vegetable earth	28
Shingle	39
Gravel	40
Compact earth	50
Chalk	55
Rubble	45
Well-drained clay	45
Wet clay	16
Loose peat	14
Firm peat	45

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(369) Can you give me a formula for a cement that will securely unite two pieces of limestone or granite? A. H. S., Martinsburg, W. Va.

ANS.—We suppose that you intend to use the cement for repairing stonework where it has been injured either before or after working. The following recipe is employed in making a composition called by mechanics "*Beaumontague*," and is largely used by stone cutters. Mix equal parts of gum dammar, white wax, and white rosin in an iron pot over a fire, and when the mixture has been melted add stone dust to make it of the consistency of dough. The stone dust should be obtained by pulverizing pieces of the same material that it is proposed to unite. In applying the material, the pieces of stone should first be heated with a hot iron, and the mixture applied with an iron spoon, the parts being kept together until the cementing material has become hard. The practice of sprinkling with cold water to hasten the setting is not to be recommended. When a very white cement is desired, it is usual to add chalk to the mixture. As spermaceti costs less than white wax, it is sometimes substituted therefor. The materials should be the best of their respective kinds, the usual retail prices being as follows: Genuine gum dammar costs 10 cents per ounce; white wax, 10 cents per ounce; spermaceti, 5 cents per ounce; white rosin, 3 ounces for 5 cents. We might add that, in first-class work, patched stonework is not tolerated by reputable architects. The only excuse for the existence of patched work is where it is desirous to retain as much of the old work as possible.

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(370) Please inform me what will kill the suction of new plaster, so that it can be worked over the same as old work, whether it be whitewashed or oil-painted? I have been informed that there is a preparation that, if applied to new work, will stop the suction, and that the new portion will not show differently from the old.
MACBETH, Fredericton, N. B.

ANS.—A coating of gold size or a thin solution of glue size is sometimes applied over new plaster repairs in order to kill the greater suction of the new

material, but, at the best, is a makeshift, as the proper way is to allow the plaster to become thoroughly dried before applying either water or oil paint. In oil paint, the wall (for first-class work) should receive a thin coating of oil, allowing the wall to absorb all it will take up. In this way the work will stand out solidly and uniformly. Any sizing material applied to walls is apt to peel.

***

(371) Kindly give me information as to an easy way of finding the proper sizes of hot-water radiators for a 10-roomed house. B. W. A., Holly, N. Y.

ANS.—The following table of ratios is often used for the ordinary class of frame dwellings that are not too much exposed:

TABLE OF RATIOS.

Apartments.	Cubic Feet Heated by 1 Sq. Ft. of Radiating Surface.
Living rooms, one side exposed	30
Living rooms, two sides exposed	28
Living rooms, three sides exposed	25
Sleeping room	25 to 35
Hall room	30 to 40
Bathroom	20 to 30

This table is constructed on the supposition that the building has an average amount of wall and glass exposure. The ratios are for direct heating with hot water at a temperature of about 160° F. in the radiators during zero weather. Due care must, however, be exercised to provide for any special conditions, such as exposure of building, material of construction, location, length and size of mains, etc., governing plant under consideration. Allowances should also be made for loose construction of doors and windows that admit large volumes of cold air. A provision should also be made for outside doors that are used frequently and open directly into a room. In estimating hot-water radiating surface it should be borne in mind that a large surface at a comparatively low temperature gives a much more pleasant atmosphere than a small surface at a high temperature. Excess of surface is no discomfort, as is the case with steam, since the temperature can easily be controlled by varying the fire, or by the valve on the radiator.

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(372) (*a*) In a single-phase alternating-current circuit, the power factor is 70.7 per cent., as the angle of lag is 45°. The apparent amperage is 100, and the voltage 1,000. I do not see why 29.3 per cent. of the total power is called idle, or lost, current, for there would never be a time when the curves of voltage and amperage would have a zero value at the same instant, as there would be were the resistance in the circuit non-inductive. (*b*) Wherein do the principles of operation of wattmeters differ from voltmeters and ammeters? (*c*) Why is it that steam is not subject to the same law that governs the action of other gases regarding the necessity for doubling the absolute temperature to double the volume and pressure? M. S. L., Noblesville, Ind.

ANS.—(*a*) In an alternating-current circuit in which the power factor is unity, the zero values of E. M. F. and current occur at the same instant. In consequence, the actual rate at which energy is being expended is equal to volts × amperes. With the insertion of inductance in the circuit the current lags behind E. M. F., the angle of lag depending on the ratio of reactance to resistance. If the former were infinitely great with regard to the latter, or if the circuit had no resistance, the current would lag 90° behind the E. M. F. The cosine of 90° being zero, it is evident that no energy would be expended under such circumstances. As every conductor possesses resistance, energy is expended in heating the conductor, though, as before stated, if its self-induction is great in comparison with its resistance, the energy expended will be correspondingly reduced. The idle current to which you refer is *wattless*, for, while it may do a considerable amount of work during one quarter period, during the next quarter period the circuit returns an equal amount. Therefore, only that portion of the cycle during which current and E. M. F. are in the same direction will represent the expenditure of power. (*b*) In the absence of definite information, we suppose that you have reference to indicating wattmeters—not those of the recording type. An indicating wattmeter is very nearly similar in construction to a voltmeter, the main difference being that there are fixed coils composed of a few turns of heavy wire. These fixed coils are connected in series with the apparatus whose power consumption it is desired to measure. In a voltmeter the field is due to a permanent magnet; as in a voltmeter, the swinging coil is shunted across the mains supplying current to the apparatus. Ammeters of modern construction are in reality millivoltmeters that measure the drop across a known resistance connected in series with the apparatus. The meter is, of course, calibrated to read amperes. (*c*) A comprehensive answer to your question would require more space than can be afforded in these columns.

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(373) How can I make a medical induction coil to be operated with one cell of dry battery, and what is the best way of constructing a circuit breaker? A. P., Cooperstown, N. D.

ANS.—See "Home Study for Electrical Workers," November, 1898, Answers to Inquiries, No. 64. Make the interrupter similar to the armature and contact post of a vibrating electric bell.

***

(374) (*a*) Can I design a common slide valve that will cut off at $\frac{1}{16}$ of the stroke and not have exhaust begin too early? (*b*) I enclose a copy of a theoretical diagram for a $\frac{1}{16}$ cut-off. What is the mean effective pressure of the diagram? (*c*) Is the diagram, as I have drawn it, constructed correctly? C. M. E. C., Chicago, Ill.

ANS.—(*a*) It is practically impossible to design a common slide valve so that cut-off may take place at $\frac{1}{16}$ of the stroke. (*b*) The mean effective pressure of the diagram you send is about 20 pounds per square inch. (*c*) It is impossible, from the data given on your diagram, to tell with certainty whether or not you have followed correct methods in its construction.

***

Referring to "The Steam-Electric Magazine," September, 1899, Mr. E. G. Elliott, Perth Amboy, N. J., writes us as follows:

"It appears that the sketch illustrating a method of measuring armature resistance is slightly in error. The diagram indicates the voltmeter connections made to the brushes. I assume that this was an oversight.

"Allow me to state that experience has shown me that the method you recommend is a reliable one, but there is room for an appreciable error in case the voltmeter connections are made to the brushes, particularly in large generators using carbon brushes. If a number of thick carbon brushes and one stud are used, it is better to use a special brush or contact piece."

[Where a special brush is used in measuring armature resistance, care should be taken that the same number of commutator segments is spanned, as is the case with the regular brushes.—ED.]

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material, but, at the best, is a makeshift, as the proper way is to allow the plaster to become thoroughly dried before applying either water or oil paint. In oil paint, the wall (for first-class work) should receive a thin coating of oil, allowing the wall to absorb all it will take up. In this way the work will stand out solidly and uniformly. Any sizing material applied to walls is apt to peel.

***

(371) Kindly give me information as to an easy way of finding the proper sizes of hot-water radiators for a 10-roomed house. B. W. A., Holly, N. Y.

ANS.—The following table of ratios is often used for the ordinary class of frame dwellings that are not too much exposed:

TABLE OF RATIOS.

Apartments.	Cubic Feet Heated by 1 Sq. Ft. of Radiating Surface.
Living rooms, one side exposed	30
Living rooms, two sides exposed	28
Living rooms, three sides exposed	25
Sleeping room	25 to 35
Hall room	30 to 40
Bathroom	20 to 30

This table is constructed on the supposition that the building has an average amount of wall and glass exposure. The ratios are for direct heating with hot water at a temperature of about 160° F. in the radiators during zero weather. Due care must, however, be exercised to provide for any special conditions, such as exposure of building, material of construction, location, length and size of mains, etc., governing plant under consideration. Allowances should also be made for loose construction of doors and windows that admit large volumes of cold air. A provision should also be made for outside doors that are used frequently and open directly into a room. In estimating hot-water radiating surface it should be borne in mind that a large surface at a comparatively low temperature gives a much more pleasant atmosphere than a small surface at a high temperature. Excess of surface is no discomfort, as is the case with steam, since the temperature can easily be controlled by varying the fire, or by the valve on the radiator.

***

(372) (a) In a single-phase alternating-current circuit, the power factor is 70.7 per cent., as the angle of lag is 45°. The apparent amperage is 100, and the voltage 1,000. I do not see why 29.3 per cent. of the total power is called idle, or lost, current, for there would never be a time when the curves of voltage and amperage would have a zero value at the same instant, as there would be were the resistance in the circuit non-inductive. (b) Wherein do the principles of operation of wattmeters differ from voltmeters and ammeters? (c) Why is it that steam is not subject to the same law that governs the action of other gases regarding the necessity for doubling the absolute temperature to double the volume and pressure?

M. S. L., Noblesville, Ind.

ANS.—(a) In an alternating-current circuit in which the power factor is unity, the zero values of E. M. F. and current occur at the same instant. In consequence, the actual rate at which energy is being expended is equal to volts × amperes. With the insertion of inductance in the circuit the current lags behind E. M. F., the angle of lag depending on the ratio of reactance to resistance. If the ... were infinitely great with regard to the ... the circuit had no resistance, the cur...

90° behind the E. M. F. The cosine of ... it is evident that no energy would ... under such circumstances. As every ... possesses resistance, energy is expended ... the conductor, though, as before stated ... induction is great in comparison with ... the energy expended will be correspond... The idle current to which you refer ... while it may do a considerable amount ... ing one quarter period, during the ... period the circuit returns an equal ... fore, only that portion of the cycle ... current and E. M. F. are in the same ... represent the expenditure of power ... absence of definite information, we ... have reference to indicating wattmeters ... the recording type. An indicating ... nearly similar in construction to ... main difference being that there ... posed of a few turns of heavy ... coils are connected in series ... whose power consumption it is ... In a voltmeter the field is due to ... as in a voltmeter, the swinging ... the mains supplying current to ... meters of modern construction ... voltmeters that measure the ... resistance connected in series ... The meter is, of course, cali... (c) A comprehensive answer ... require more space than ... columns.

(373) How can I make ... be operated with one ... is the best way of con...

ANS.—See "House S... November, 1898. Answ... the interrupter simila... post of a vibrating ...

(374) (a) Can I ... will cut off at ... begin too early ... diagram for a ... pressure of the di... have drawn it, ...

ANS.—(a) It is ... common slide ... at $\frac{1}{8}$ of the stroke ... of the diagram ... square inch, ... given on your ... or not you ha... construction.

Referring ... tember, 18... writes us as ...

"It appe... of measuring ... The diagra... made to the ... oversight.

"Allow me ... that the meth... but there is ... the voltm... particularly ... If a numb... are used ...

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...UARY, 1900. No. 12.

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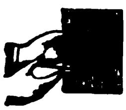

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Page XXII.

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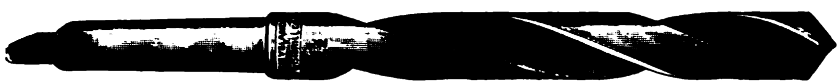

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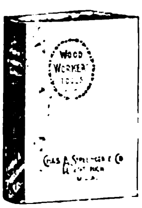

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Vol. IV. JANUARY, 1900. No. 12.

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SCIENCE AND INDUSTRY

Vol. IV. JANUARY, 1900 No. 12.

THE MANUFACTURE OF VINEGAR.

Warren P. Smiley.

THE PROCESS OF CHANGING CIDER INTO VINEGAR, AND THE CHEMICAL REACTIONS INVOLVED. SOME OF THE OTHER SOURCES OF SUPPLY.

WE ARE all familiar with the fact that when sweet cider, freshly pressed from apples, is allowed to stand exposed to air, it gradually loses its sweet taste, and an alcoholic liquor (hard cider) is formed. If allowed to stand longer, the change continues, the liquid acquires a sour taste, and after a time the alcohol almost, or entirely, disappears, and an acid liquid, known as vinegar, remains. This method of obtaining vinegar is largely used in this country, and we are all familiar with it, but we seldom think of the chemical reactions that cause the changes in the properties of the liquid as it passes from sweet cider to vinegar. The process consists essentially in a breaking up of the complex sugar molecules into simpler molecules of alcohol and carbon dioxide, and a further change from alcohol to acetic acid, and is known as fermentation. Before proceeding to the processes of manufacture, let us turn aside to briefly consider the phenomena of fermentation upon which these processes depend.

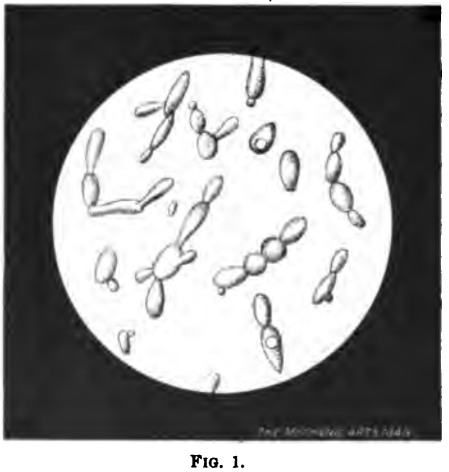

FIG. 1.

Fermentation is a very interesting phenomenon, and has of late received considerable attention at the hands of chemists, but it must be confessed that there is still much to be learned in regard to it. In its broadest sense the term is applied to those changes by which, in the presence of a ferment, many organic compounds, principally the carbohydrates, are decomposed into simpler ones. In its most restricted sense the term is used to denote the decomposition of sugar with the production of alcohol. At least three kinds of fermentation are now generally recognized, viz.: alcoholic, in which alcohol is produced from the sugar; acetic, in which acetic acid is produced; and lactic, in which lactic acid is the principal product. There are many different ferments, and they differ largely in properties, but those with which we are concerned at present are minute vegetable growths. Although it is not known how these ferments produce the chemical changes observed, they appear to induce such changes by growing in the solution without consuming any of the sugar. It also appears that albuminoid matter and phosphates are necessary for their growth. When a solution containing nitrogenous matter, phosphates, and glucose—the variety of sugar present in fruits—is left standing exposed to the air at a temperature ranging from 50° to 75° F., the microscopic spores floating in the air fall into the liquid and begin to grow by the addition of cells, or the budding process, as it is called. During this growth the sugar is

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steadily converted into alcohol and carbon dioxide, 1 molecule of sugar producing 2 molecules each of alcohol and carbon dioxide, according to the equation:

$$\underset{\text{sugar}}{C_6H_{12}O_6} = \underset{\text{alcohol}}{2C_2H_5OH} + \underset{\text{carbon dioxide}}{2CO_2}$$

In Fig. 1, one of the plants producing alcoholic fermentation is shown as it appears under the microscope. It should be remarked at this point that cane sugar $C_{12}H_{22}O_{11}$ is not directly changed into alcohol and carbon dioxide by ferments, but if it is first treated with dilute acid, or is allowed to stand in a solution in which the ferment is growing, it is converted into invert sugar, and then the change to alcohol and carbon dioxide takes place according to the above equation.

If the solution is allowed to stand exposed to the air at a moderate temperature, the change will not stop when the sugar is converted into alcohol and carbon dioxide, but the alcohol will be changed to acetic acid. This change from alcohol C_2H_5OH to acetic acid $C_2H_4O_2$ is an oxidation, as will appear from their formulas. The spores of acetic ferment (*mycoderma aceti*) floating in the air fall into the liquid and begin to grow, not as in the case of the alcoholic ferment, by budding, but by splitting or fissure of the cells. It is not known just how this plant induces the change, but under its influence the alcohol is oxidized to acetic acid; and water is produced according to the equation:

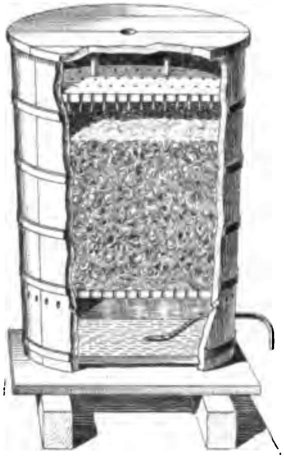


FIG. 2.

$$\underset{\text{alcohol}}{C_2H_5OH} + \underset{\text{oxygen}}{O_2} = \underset{\text{acetic acid}}{C_2H_4O_2} + \underset{\text{water}}{H_2O}$$

The conditions most favorable for acetic fermentation are:

1. A weak solution of alcohol, containing not more than 12 per cent. of this compound, together with nitrogenous matter and phosphates necessary for the growth of the plant.

2. Acetic ferments—*mycoderma aceti*, etc.

3. Abundant access of air, which supplies oxygen.

4. A temperature ranging from 68° to 95° F.

Under these conditions, the ferment, falling on the surface of the liquid, commences to grow, and forms a gelatinous film that becomes heavy and falls to the bottom, while the alcohol is oxidized to acetic acid, according to the above equation. Another film forms and sinks to the bottom, and this continues as long as the liquid contains food for the ferment. The gelatinous matter that collects at the bottom is a mass of the fissure cells, and is known as "mother of vinegar."

From what has been said it is evident that cider is well adapted for the production of vinegar. Apples contain sugar, together with phosphates and nitrogenous matter, and these latter constituents in the juice furnish the food necessary for the growth of the ferments. When allowed to stand exposed to air at a moderate temperature, the ferment spores fall into it and grow, changing the sugar to alcohol and the alcohol to acetic acid. Although the reactions mentioned are the principal and essential ones, others also take place. Some acetic ether is formed, and this, together with smaller quantities of other substances, gives the vinegar its pleasant aromatic odor and flavor. The process of manufacture is the familiar one of allowing the barrels containing the cider to lie in the sun or in a warm cellar with the bung holes open. It is sometimes made a progressive process, however, by adding fresh quantities of cider from time to time, and adding some mother of vinegar to accelerate the change.

It is evident, then, that for the production of a strong vinegar, sweet apples are the best, for it is the sugar in the juice that produces the acetic acid. The malic acid that gives the sour flavor to apples is unimportant in the production of vinegar. The writer was called upon, not long since, to analyze a sample of vinegar that the producer said was too strong for household use. He stated that it was made from sweet, juicy apples, and could not understand why it should be so sour. The explanation, of course, was very simple. The sweet flavor of the apples was due to a large amount of sugar, and this, on fermentation, yielded a large amount of acetic acid. The analysis showed the percentage of acetic acid in this sample to be exceptionally high.

Though cider is largely used in this country for the production of vinegar, it is not its only source, nor is it the principal one, if the world's supply is considered. Vinegar, as

we have seen, can be produced from any dilute alcohol solution containing food for the acetic ferment, and several such solutions are used. In Europe—principally in France—large quantities of vinegar are annually produced from wine. Vinegar is also made in Germany from brandy, in England from malt wort, or beer, and in this country from whisky. The following processes are in use for the manufacture of vinegar from these substances.

1. *The Orleans Process.*—This method, by which vinegar is produced from wine in France and Germany, is the oldest one now in use. The "mother casks," which are made from oak and hold from 50 to 100 gallons, are first steamed out and then filled to one-third their capacity with boiling vinegar, to sour them. The wine to be acetified, which has been allowed to stand over wine lees for a time, and then clarified by being passed through vats containing beech shavings, is now added in quantities of 10 liters to each cask every 8 days. When the casks are rather more than half full, one-third of the contents are siphoned out into storage vats, and the addition of wine continued, as before. The process is continuous, and the mother casks, or acetifiers, may be used in this way for several years, until the sediment of argols, yeast, and other impurities makes it necessary to clean them. A temperature between 75° and 80° F. has been found best for this process. The vinegar made by this process has a very pleasant aroma and flavor. That made from white wine is considered the best.

2. *The Quick-Vinegar Process.*—This process is used in Germany for the production of vinegar from brandy, and in this country for its production from whisky. The acetifiers in this case are upright casks varying from 6 to 12 feet in height and from 3 to 5 feet in diameter. A section of one of these casks is shown in Fig. 2. About a foot above the true bottom it has a false bottom, perforated like a sieve, and just beneath this false bottom a series of holes extending entirely around the cask is bored slanting downward, through which the air enters during the process. Beech shavings that have been boiled in water and dried, and then soured by soaking in warm vinegar for 24 hours, are filled in above the false bottom. Above these is placed a disk perforated by small holes that are loosely filled with pack thread, and by four large glass tubes for the air to pass through. The cask is then closed with a cover having a hole in the center, through which the alcoholic liquid is poured, and through which the air passes from the flask. The diluted liquor, which is generally mixed with malt infusion, to furnish food for the ferment, is added at the top, and as it commences to oxidize the temperature rises, causing the air in the cask to pass out at the top, and fresh air enters through the holes under the false bottom to take its place. Thus the liquid trickling downward through the shavings is met by a current of air passing upward, and, under the influence of the ferment, is rapidly oxidized. The

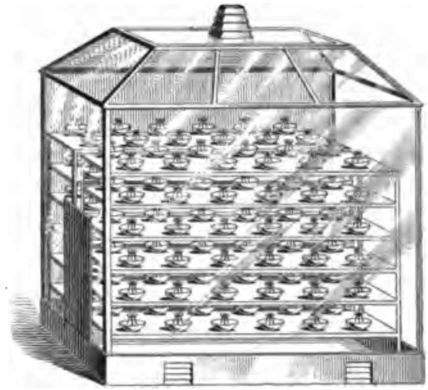


FIG. 3.

partially oxidized liquid collecting in the bottom of the cask flows into the top of another cask, and the oxidation continues. If the original liquid does not contain more than 4 per cent. of alcohol, that drawn off from the second cask will be good vinegar. A temperature of about 95° F. should be maintained in the casks, for if the temperature is much lower, the oxidation is too slow, and if much higher, too much alcohol and aldehyde (a volatile oxidation product between alcohol and acetic acid) are lost by evaporation.

3. *Malt Vinegar.* — The manufacture of vinegar from malt wort is similar to the quick-vinegar process, but the casks used are much larger, holding from 8,000 to 10,000 gallons, and are somewhat differently constructed. Bundles of birch twigs that have been repeatedly boiled, to free them from juice and coloring matter, are placed upon the perforated false bottom. The malt wort is fed in below the false bottom, where it is warmed by steam pipes. It is then pumped to the top, sprinkled over the twigs, and allowed to trickle through them. This is continued until acetification is complete. The temperature is raised to 110° F. at the beginning of this process, but is soon allowed

to fall to 100° F., at which it is maintained throughout the remainder of the process.

4. *Pasteur's Process.*—In this process, small quantities of phosphates of potassium, magnesium, and calcium are mixed with a solution containing 2 per cent. of alcohol and 1 per cent. of vinegar, and acetic ferment (*mycoderma aceti*) is added. The plant grows rapidly, spreading over the surface of the liquid, and the alcohol is oxidized to acetic acid. When half the alcohol is changed to acetic acid, small quantities of wine or alcohol mixed with beer are added daily, until the oxidation slackens. The vinegar is then drawn off, and the mother of vinegar is washed and used with a freshly prepared mixture. Vinegar made in this way is said to possess the pleasant aroma for which wine vinegar is so highly esteemed.

5. *Dobereiner's Process.*—As the production of vinegar from an alcoholic liquid depends on the oxidation of the alcohol to acetic acid, it was sought to produce this change without the aid of a ferment, and Dobereiner succeeded in accomplishing this by means of platinum black, which has the power of occluding oxygen and giving it up to alcohol vapors when they come in contact with it. The apparatus for the production of vinegar by this process is shown in Fig. 3. It consists of a small glass house containing a number of shelves, and provided with ventilators in the roof and at the bottom, by means of which the air supply may be regulated. Upon each shelf are placed a number of porcelain dishes containing the alcohol to be acetified, and in each dish is placed a porcelain tripod to support a watch glass containing platinum black, or spongy platinum. The interior of the house is heated to about 91° F. by means of a steam pipe. This slowly evaporates the alcohol, and its vapors, on coming in contact with the platinum black, are rapidly changed to acetic acid. So long as the circulation of air is kept up, the platinum black will occlude oxygen and give it up to the alcohol; hence, the same quantity of platinum black may be used for the production of an indefinite amount of vinegar. If this process is to be carried on without waste, the air passing out of the apparatus must be conducted through a condenser, to obtain the alcohol and acetic acid carried with it.

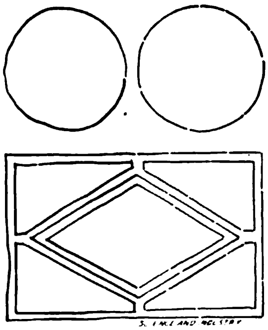
It has been impossible, in the allotted space, to give more than a brief outline of the principles and processes involved, but this whole matter is a very interesting subject for careful study and experiment.

RAPID SKETCHING.

W. F. S.

SKETCHING is the shorthand of drawing, and therefore, to be of practical service to the artisan, must be placed on an established basis equally rapid and communicative with that of stenography.

A pencil and a scrap of paper in the hands of a mechanic with a knowledge of rapid sketching will enable him in a few strokes to record the ideas or instructions of others, as well as illustrate his own, thus saving hours of valuable time and a volume of words in establishing a mutual understanding. Now, there is no method better adapted to acquire this end than an outline drawing, sometimes called a *single-line sketch*—devoid of detail, color, or shade, yet in its skeleton simplicity conveying to the mind all that is absolutely necessary to be known.



As much depends, in everything, on getting the right start, we will give a few points in that direction. Do not try to draw a straight long line; if you desire such, draw a succession of short disconnected lines; practice alone will bring satisfactory results. Curved lines should always be broken at intervals, and a circle should never be drawn freehand with one continuous line, as only one man (Giotto) has been credited with doing that successfully. In forming a circle, make at least two strokes—one at the top and the other at the bottom; still more are even better. It is not necessary that the lines should be perfectly true, as an uneven line in most cases is much more desirable. The accompanying illustration shows the relative value of the right and wrong in freehand drawing.

PLUMBING A HALF-TIMBERED COTTAGE.

Thos. N. Thomson.

HOW THE DRAINAGE SYSTEM IS ARRANGED—VENTILATION OF THE SYSTEM—HOW TO TRAP THE WORK PROPERLY.

THE plumbing of a cottage such as described in the serial article by Mr. C. S. Kaiser, entitled "A Half-Timbered Cottage," which was begun in the August, 1899, issue of "The Building Trades Magazine," consists of (*a*) the plumbing fixtures, i. e., the laundry tubs in the basement, one kitchen sink, one water closet, one wash basin, one bath, one range and boiler; (*b*) the drainage system; (*c*) the water-supply system. The plumbing fixtures have already been described and illustrated, so in this article we will confine our thoughts to the drainage and water-service piping required for the fixtures.

The *drainage system* is composed of all pipes necessarily required to convey waste matter from the fixtures to the place chosen for its disposal; also, all pipes, etc. necessarily required to prevent drain or sewer gases from entering the building, or from accumulating inside the system.

In a general way, the drainage systems of all small buildings, like the "Half-Timbered Cottage" with which we have lately become familiar, may be subdivided as follows: (1) The main house drain (and its lateral branches), which runs through the cellar with an easy pitch. (2) The soil pipe, which runs vertically from the highest end of the main house drain up to and through the roof; also the branches that extend from the soil pipe to receive discharges from the plumbing fixtures. (3) Vent pipes and their branches that connect to the crowns of the fixture traps and discharge through the roof separately or otherwise; also, a fresh-air inlet pipe, which is necessarily required when a trap is placed on the main house drain, to prevent gases in the street sewer from entering the house-drainage system.

THE HOUSE SEWER.

To design a drainage system for any house, we should first know where the sewage matter is to be discharged. In the case of our half-timbered cottage, we will suppose the place of disposal to be a street sewer of the ordinary kind. If the town or city where this house is to be built has any self-respect worthy of the name, it will not allow any person to make connections to its sewers, except the party who is qualified and duly authorized to do so. Next to the city's own expert on sewer connections comes the plumber. He can and does make a good connection when he gets a fair chance. But woe betide the municipal authorities that allow Tom, Dick, and Harry to tap the sewers where and how they please, for the sewers, no matter how good they are, will soon become so thoroughly choked that even the sewer rats will scarcely be able to squeeze through. We will not tell you how "not to make" the sewer connection, for you can conceive that yourself if you examine Fig. 1 carefully. This illustration shows the very best connection you can get. A Y branch has been left on the street sewer *a* and it does not droop down like so many imperfect Y branches. It is tilted up a little, which helps to prevent sewage from backing into the house sewer *b*. An obtuse bend may be used to bring the branch around to the square, if so desired, as shown by dotted lines.

The house sewer should run as straight as a gun barrel from the street sewer to the main-drain trap, and should be laid with a pitch of at least 1 in 60. One-fourth of an inch fall per foot is found to be an excellent pitch. This pipe is usually 6-inch vitrified terra cotta, if the ground on which it lies is hard and solid natural ground; but, if it is filled in, then the pipe should be extra heavy cast iron, thoroughly coated both outside and inside with a non-soluble, non-corrodible, durable covering that will prevent corrosion of the pipe. The earthenware pipe should be jointed with the best quality of Portland cement and clean sharp sand (half and half), while the cast-iron house sewer should have its joints all calked with lead and oakum. As earthenware pipe is very liable to be broken or disjointed underground, the health department rules and regulations advise that the earthen sewer should not come within 5 feet of the foundation walls of the building; in fact, the best health authorities make this regulation compulsory. It is customary, therefore, in all respectable neighborhoods—that is to say, in neighborhoods where the people have enough

intelligent perception to see the necessity of having healthful homes and sanitary surroundings—to run the cast-iron house drain through the foundation wall and extend it out about 5 or 10 feet, where it connects with an "increasing piece" and a cement joint to the earthenware sewer.

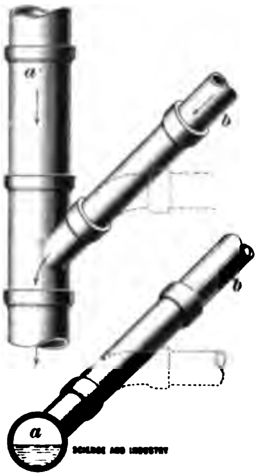


FIG. 1.

The proper size for the house sewer of an ordinary residence, like the one under consideration, is from 5 to 6 inches if of earthenware, and from 4 to 5 inches if of cast iron. The reason for the difference in size is that earthenware pipes are seldom as perfect as they should be. Near-sighted theorists, who find the sizes of small sewers with calculating machines, may tell us that there should be no difference in the sizes—that the material has no bearing in the matter, etc.; but this is nonsense, and we find practical proof of it every day.

THE SYSTEM IN GENERAL.

Before going into the details of the drainage system inside the building, it would be well for our readers to get acquainted with the names and duties of the several parts of the system; therefore, we take pleasure in calling attention to the isometric drawing, Fig. 2. This illustrates the general arrangement of all the drainage pipes in the building, and lets the layman see that the plumbers put in more pipes than the public gives them credit for. But the pipes shown in Fig. 2 are not all, by any means, for the water-distributing services, risers, branches, etc. are not shown in this figure. It is safe to count on nearly twice as many as are here shown. We do not show the water pipes in Fig. 2 at all; if we did, the sketch would be so complex that few people would care to "follow it up."

Now, let us study Fig. 2 and get acquainted with the whys and wherefores of its several parts. Begin at the very bottom, where the 4-inch cast-iron house sewer comes in through the cellar wall. The main drain, which is a continuation of the house sewer, runs along under the cellar floor and continues out through the rear cellar wall, to take in the leaders *a*, *a*, as shown in Fig. 3. But a main-drain trap is placed upon it at the front cellar wall, and the same kind of a trap, but with another name (rain-water trap), is located at the rear cellar wall.

The branches that carry off waste matter from the plumbing fixtures connect to the main drain at points between these traps, and the two front leaders *b*, *b* are trapped before they connect to the main drain. The water closet is the only plumbing fixture shown; the relative positions of the others are indicated by their respective traps. The course taken by the water discharged from any fixture can be found by tracking the waste-pipe lines. But the mere matter of carrying away the sewage is one of the least important items in the structure. Many years ago that was all the plumbers thought about, so the soil and waste pipes all terminated at their respective fixtures and seldom ran any higher. Serious outbreaks of terrible diseases and plagues soon opened the eyes of the world to the fact that there were other things to be considered than the mere putting in of pipes to carry off dirty water and its legitimate accompaniments.

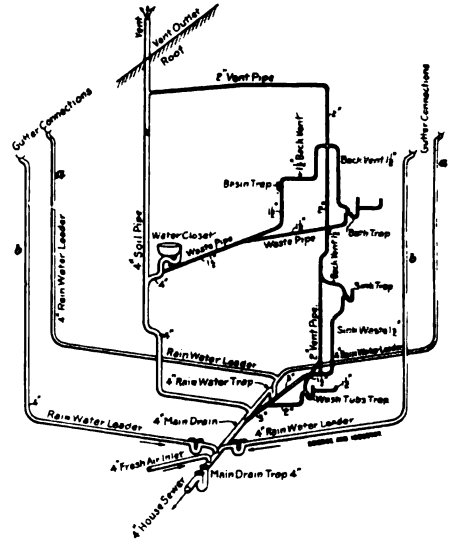


FIG. 2.

Physicians began to shout *sewer gas!* Scientific men gave the great problem of house drainage much study, and ultimately decided that the entire drainage system of a building should be ventilated so that the sewer gas might escape to the atmosphere above the

roof and thus mix with the four winds of heaven, instead of filling the homes of the people. At the same time many plumbers began to get very proud indeed, not because the world looked on them as the indirect cause of so much suffering and death, but simply because a new era had opened up, and they, to distinguish themselves from their fellows, christened themselves sanitary engineers. But things are now changed to those pipes through which no water can flow. They are the ventilation pipes, called vent pipes for short. They are all arranged to accomplish the important result of producing a constant changing of the air throughout the drainage system, so that the gas produced by the decomposition of organic matter in the system will be diluted with fresh air and made as harmless as possible; also, to supply air freely to the crowns

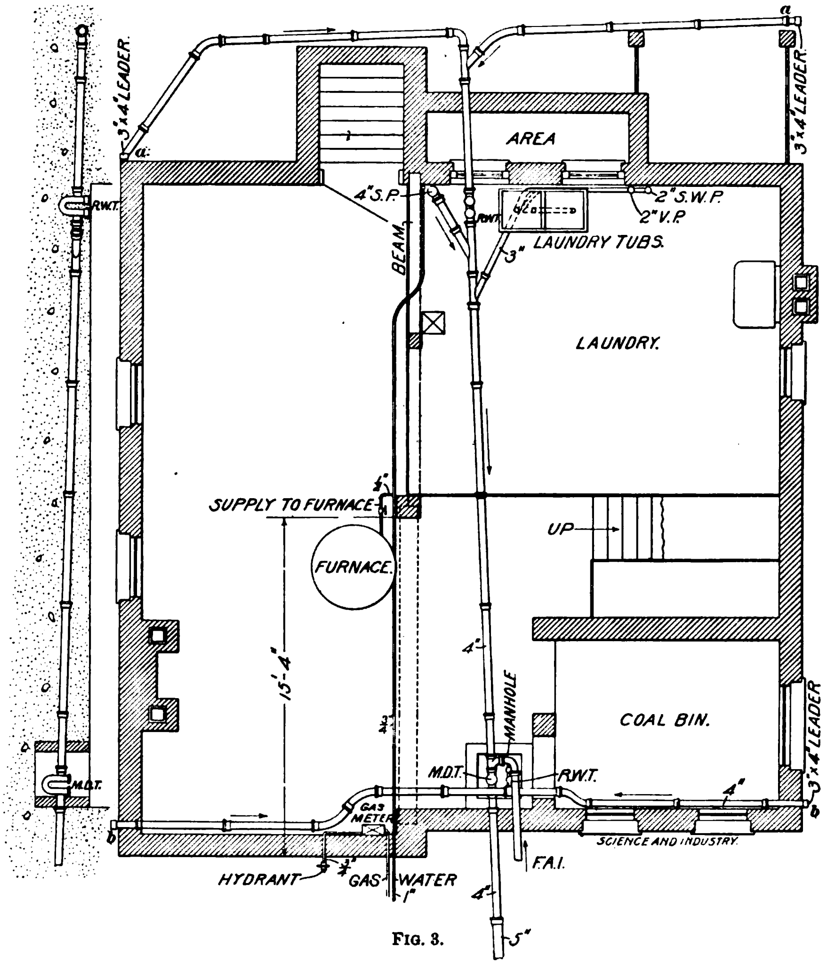


FIG. 3.

altogether. Most of the lead-pipe pioneers have gone up to a better land, and their successors are doing the scientific work below on the new plan—plumbers now are plumbers, while sanitary engineers are sanitary engineers.

But, to come back to the question of ventilation of house-drainage work, we would again draw attention to Fig. 2—this time of the fixture traps, and thus prevent their seals from being spoiled by siphonage. It will be understood that these traps are used to keep in the sewer gas and at the same time allow water to flow away from the fixtures.

Now, if the reader will follow up the vent pipes, and think a little bit, he will discover the facts that each branch in the house

system will receive a thorough change of air, for the pipes are all arranged to facilitate

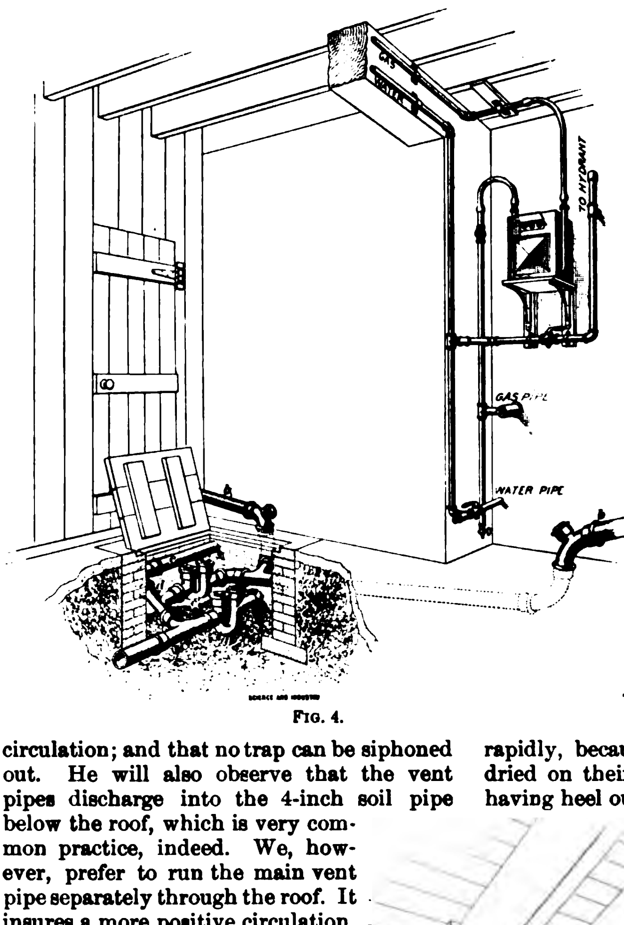


FIG. 4.

circulation; and that no trap can be siphoned out. He will also observe that the vent pipes discharge into the 4-inch soil pipe below the roof, which is very common practice, indeed. We, however, prefer to run the main vent pipe separately through the roof. It insures a more positive circulation.

A careful study of Fig. 3, which is a plan of the cellar showing the drainage pipes underground, will help the reader to comprehend how a first-class system of drainage may be laid for an ordinary small building. A brick manhole is built around the *M. D. T.*, or main-drain trap, for access to this point. The *R. W. T.*, or rain-water trap, at the opposite wall, has no manhole, for its handholes are flush with the floor (see sectional view, Fig. 3). The abbreviations on this figure can be understood by reference to the isometric drawing.

Fig. 4 is a perspective view of the corner where the pipes come in through the front wall, and clearly shows an excellent method of arranging them in the manhole. The main-drain trap *a* is provided with two brass screw-cap clean-outs that are flush with the floor of the manhole. A rain-water trap *c*, which traps both the front leaders *b*, *b*, instead of two separate traps, as shown in Fig. 2, is set a little higher than the main-drain trap, so that the rain water may discharge into the sanitary tee fitting *d* on the fresh-air inlet pipe *e*. Each underground trap is thus accessible and can easily be cleared at any time. By joining the two front leaders together, and using one trap for both, instead of one trap for each, as shown in Fig. 2, which is common practice, we not only save the cost of a trap, but also provide for ventilation of the leaders by allowing either one to act as an outlet for the other. In Fig. 2 the front leaders are dead ends—which means that there cannot be a circulation of air through them. Dead-end leaders, as a rule, corrode rapidly, because they cannot be properly dried on their inner surfaces. Two bends having heel outlets are attached on the front

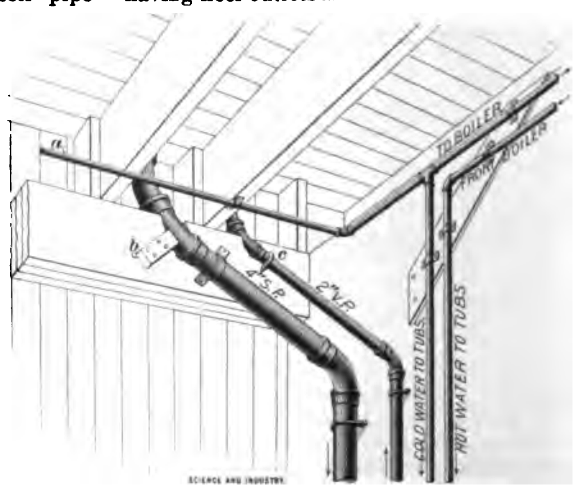


FIG. 5.

leaders where they turn down into the concrete floor, and brass screw-cap clean-outs are also calked into them for the purpose

of clearing any chokage that may occur in the bends of the leaders under the floor. These clean-outs often prove very useful, for twigs, leaves, etc. occasionally choke leader pipes.

In Fig. 3 it will be noticed that the 4-inch soil pipe *S. P.* runs up alongside of an overhead beam (also shown in Fig. 5), which carries a partition on the first floor and the joists as well. But, as the soil pipe is required to be run inside the partition, it follows that an offset must be on the soil pipe to bring it over the top of the beam and between the joists. Fig. 5 illustrates this admirably, and at the same time shows how the 2-inch vent pipe *V. P.* could be run alongside the soil pipe if desired.

Owing to the fact that the pipe crosses the beam close to its point of support, it is quite safe to notch the corner of the beam a little, as shown, to get room for the fittings. An iron strap clasps the 4-inch pipe tightly against the side of the beam, while a block *b* helps to take up the dead weight of the stack above. A common pipe hook *c* holds in the 2-inch pipe. The pipe *a* is a ¾-inch or 1-inch galvanized-iron pipe that brings in water from the street mains. The remainder is self-explanatory.

Now we have finished in the cellar. Let us go up stairs to the bathroom on the second floor, rear. Fig. 6 shows it in the rough state. The carpenters have just got the building covered, but the floors are not laid yet. The plumber's pipes are all in, however, and are ready for testing, or, if they have already been tested, then everything is in condition for the other mechanics to come and finish their work in the bathroom. After they are all finished, the plumber comes back to put in the bath, basin, and water closet.

The branch *a* taken from the soil pipe *b*, is simply a lead bend. It is joined to the sanitary tee, or T Y, on the vertical stack, by means of a brass ferrule, one end of which is wiped to the lead bend, and the other end is calked in the socket of the T Y with lead and oakum. All the joints in the cast-iron pipe should be calked with lead and oakum. If any person uses cement or putty for this work, he should be immediately removed from the premises, and his work overhauled and made right by a first-class mechanic.

The waste pipes *c* for the wash basin and *d* for the bath, are both made of lead, and it will be noticed that they are both uniformly supported on wooden shelves. If the owner of a building pinches the plumber too much on the contract price, or, what is still worse, if he allows a general contractor to sublet the contract for plumbing, these minute yet very important details will invariably be omitted, and the lead waste pipes will be

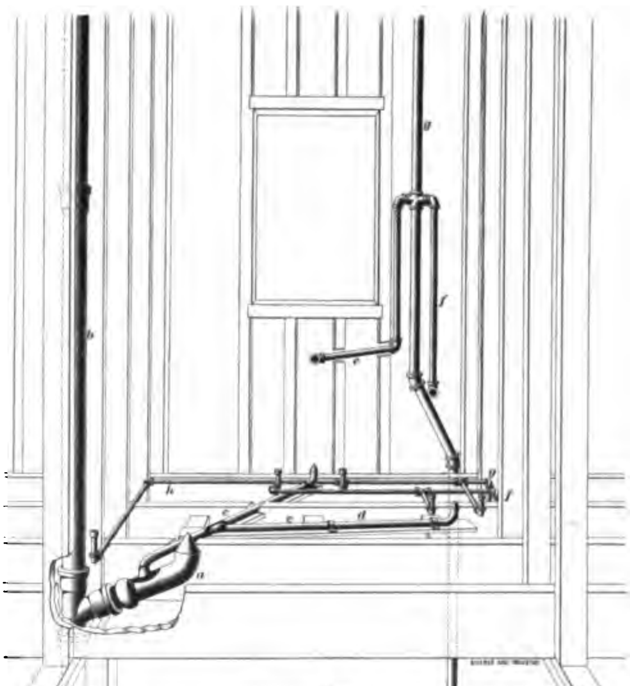


FIG. 6.

laid minus supports. The result of this neglect soon speaks in its own way, for the waste pipes will sag between the joists and soon become obstructed either by solid matter or by air locks, which are about as bad.

Owing to the fact that the water closet is set quite close to the soil pipe, it is deemed unnecessary by many authorities to back-vent the closet branch; but if any fixtures discharge into the soil pipe at a point higher than this closet branch, it would be advisable to back-vent it with a 2-inch pipe. The basin is back-vented by a 1¼- or 1½-inch pipe *e*, and the bath by a similar pipe *f*, both of which

connect to the 2-inch vent pipe *g*, which is continued down to back-vent the sink on the first floor and the laundry tubs in the basement. It is continued up full size between the studding to the attic, where it crosses over the bathroom ceiling and joins the 4-inch soil pipe under the roof; it may be continued up through the roof separately, as previously mentioned.

The matter of piping a building for hot- and cold-water supply is not so intricate or so important as for drainage, when a good street pressure can be obtained. But it is important, nevertheless, and is really worthy of more consideration than we have space to give it at present. Therefore we will postpone this part of the subject, hoping to describe it in a future issue.

THE OPEN FEEDWATER HEATER.

Joseph Cawley.

THE SAVING DUE TO HEATING THE FEEDWATER—CLAIMS FOR THE OPEN TYPE OF HEATER. THE CONSTRUCTION OF A MODERN HEATER.

"A DOLLAR saved is a dollar gained," is an old saying that is true whether applied to a steam plant or to anything else.

In pace with the rapid progress of engineering, there are appliances being invented from time to time to overcome this or that difficulty, or to partially or entirely prevent this or that waste in steam plants. These devices have, in the past, been looked on by many short-sighted steam users more or less as luxuries; but the efficiency attained by the use of appliances designed by engineers of authority, is gradually making them an actual necessity in a modern steam plant. Along with other appliances in the steam-engineering line, the feedwater heater has now taken its place as a necessary adjunct to the steam plant, and, as an economical appliance, it is considered by many to stand without a superior. Its first cost is the only expense, as its operation and maintenance cost nothing. It is automatic in its operation, and requires the least attention of any appliance connected with the generation of steam. The economy accomplished by the use of a feedwater heater utilizing waste heat is so apparent to any one desiring to minimize the cost of steam generation, that even quite small plants are now installing them as a matter of necessity.

The steam, after being generated at the boiler and performing its work in the cylinder of the steam engine, in place of being exhausted into the atmosphere and its heat wasted, is utilized by the feedwater heater in heating the feedwater to a high temperature, 212° Fahrenheit being the highest temperature attainable by the use of exhaust steam in an open heater.

Inasmuch as it takes about 5 pounds of coal per horsepower per hour in the ordinary small non-condensing plant to generate this steam, it can readily be seen that by utilizing the exhaust steam in the feedwater heater to heat the water introduced to the boiler, in place of allowing it to go to waste, an unquestionable economy is obtained; it being a fact, in strict accordance with the laws of nature, that the higher the temperature of the feedwater entering a boiler, the less the consumption of coal. The saving obtainable varies from 15 per cent. to 25 per cent., according to varying conditions.

Another source of economy that the feedwater heater should be given credit for is that due to the purification of the water incidental to the heating. This especially applies to the open type of heater, where, by the water coming in direct contact with the steam, and by being distributed over large surfaces and finally allowed to settle in a large sedimentation reservoir, it rids itself not only of those ingredients in the water that precipitate at a temperature of 212°, such as carbonate of lime, but also to a large extent of the matter held in suspension in the water. It is a well-known fact that these foreign ingredients deposit on the inside of the boiler, thus obstructing the transfer to the water of the heat generated in the furnace. It is readily seen that more fuel is required to heat water through scale and steel than through steel alone, scale being a non-conductor of heat. Actual tests have shown that a scale $\frac{1}{16}$ of an inch thick requires 15 per cent. more fuel, and that as the scale accumulates the ratio increases.

In addition to the sources of economy mentioned, there is also a great saving in

other directions due to the use of a feedwater heater, such as the reduction of the unequal strains due to expansion and contraction of the boiler shell caused by the introduction of cold water; the prevention of overheating and corrosion of the steel shell due to the accumulation of scale; the tendency to prevent explosions; and the reduction of stoppages and delays incidental to the cleaning and repairing of the boilers.

Both the open and closed (or tubular) types of heaters have their advantages and disadvantages, but the advantages of the open heater not being as well known as those of the closed heater, the writer will here confine himself to the open type.

Years of daily use have demonstrated that the open type of heater is on equal footing with the closed type. The fact that it is being used by a large number of the representative and largest steam users that have had years of experience in the use of heaters, is good evidence of the fact that it possesses the advantages of efficiency, economy, and durability claimed for it by its advocates. A good heater should not only possess the advantages just given, but its construction should be as simple and efficient as possible. This requirement is possessed by the standard makes of open heaters, the parts being few and so arranged that each part is easily accessible for inspection or cleaning. Various improvements in the construction have been made since the open type of heater was first put on the market; these improvements being the result of years of experience of the best engineers with this type.

Some of the main points of superiority that the manufacturers of the leading makes of open-type heaters claim for their appliances are given below, and as the different makes have different advantages, mention will only be made of those points that are claimed by all. The claims for the open heater using exhaust steam are:

1. Effective heating and precipitating surface.

2. The feedwater is heated to a temperature of from 210° to 212° without the use of fuel.

3. Effective devices for preventing the oil and floating impurities from entering the boilers, the methods in some cases being purely mechanical, and thus dispensing with filtering materials, so troublesome in cleaning and so expensive in maintenance.

4. Devices insuring an even and thorough distribution of the feedwater.

5. An efficient and automatic regulation of the feedwater supply to the pump.

6. A very large steam space, allowing a free condensation of the exhaust steam, the majority of which can be returned to the boiler, thus reducing the amount of cold water to be taken from the water supply. Where water must be paid for by the 1,000 gallons, this represents a saving of considerable money.

7. Large hot-water reservoirs and settling chambers, allowing a better purification of the feedwater.

8. Methods for the removing of oil and other floating impurities, such as surface blow-offs, etc.

9. Much stress is also laid on the fact that the open type of heater is so easily cleaned, all makes of open heaters having doors through which the pans can be cleaned or removed. Some manufacturers have what are known as "revolvable pans," and this type can be thoroughly cleaned without removing the pans at all.

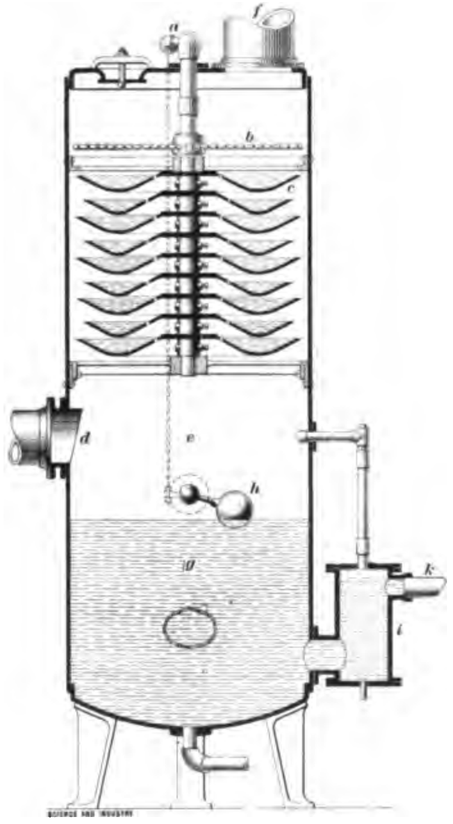
The construction of a modern open exhaust heater is shown in the accompanying figure. The cold water is admitted to the heater through a balanced valve *a*. It then passes through the inlet pipe in the center of the upper head to a spraying device *b*, located immediately above the pans. In passing through this spraying device, the water is distributed evenly in a very fine spray to the upper pan *c*. From the inner edge of the upper pan it falls vertically to the pan below, and from this pan over the outer edge to the one beneath, and so on through the whole series. The pans being arranged so as to give the water a zigzag travel from the one to the other, two fine cylindrical sheets of water are maintained, one each on the inner and outer edges of the pans.

The exhaust steam enters at *d*, immediately below the distributing pans, and passes into a large steam space *e*, from which it rises slowly, coming into direct contact with the fine sheets of falling water. Some of the steam is condensed by coming in contact with the cool water; the remainder passes into the atmosphere through the outlet connection *f* on top of the heater. The feedwater being spread into large thin sheets, on meeting the exhaust steam readily absorbs its heat until the highest temperature attainable (212° Fahrenheit) is reached. The purification of the feedwater also takes place at this point in the heater, the water depositing such impurities as can be precipitated at a temperature of 212° Fahrenheit in the pans. After leaving the pans, the water falls through the steam space to the water

reservoir and sedimentation chamber g in the lower part of the shell.

The volume of this reservoir is usually made large to provide a quiet place for the water, thus permitting a free and undisturbed settling of the foreign matter held in mechanical suspension in the water coming from the pans. Some users insert hay, etc. in this reservoir to help purify the water, but this is deemed unnecessary.

The water level is maintained in this reservoir by means of a float h, which operates the



balance valve a of the cold-water supply pipe on the top of the heater through two cranks and a connecting-rod. Should the water become low, the float falls and opens the balance valve, thus admitting more water. In the event of too much water, the float rises and shuts off the valve. An automatic regulation of the water supply is by this means maintained at all times, requiring no attention from the man in charge beyond a casual look at the gauge glass placed at the water-level on the outside of the heater. As previously mentioned, a further purification of the water takes place in this reservoir, the mud and heavier impurities settling to the bottom of the shell, where they can be blown off. The oil and lighter impurities float on top of the water, and are sometimes taken care of by a skimming apparatus or some similar device.

A number of different devices for separating the oil are used, and as most engineers prefer the one they know best, the writer will merely mention one of the many that seem to give perfect satisfaction. It is in the shape of a small cylinder i placed on the outside of the shell, connected to the water reservoir by a large flanged connection at the point shown. It is also connected on top by a pipe to the steam space of the heater. The feed-pump takes its water supply through the suction pipe k attached to the upper part of this small cylinder. The object of connecting the top of the separator i with the steam space of the shell is to prevent the water level in the shell from falling to any extent below the level of the pump connection. As soon as it falls slightly below this level, steam from the steam space of the heater will flow into the top of the separator and thence into the suction end of the pump, thus preventing the latter from taking any more water from the heater. It naturally follows from this construction that the oil and other floating impurities can never enter the separator, and consequently cannot be pumped into the boiler.

The objections raised to the open type of heater, by those that favor the closed type, are as follows:

1. Oil is carried to the boiler.
2. The pumps will not take proper care of the hot water.

In regard to the oil, it need only be said that the methods adopted by various manufacturers of open-type feedwater heaters, after long years of daily operation, have proved to be most efficient.

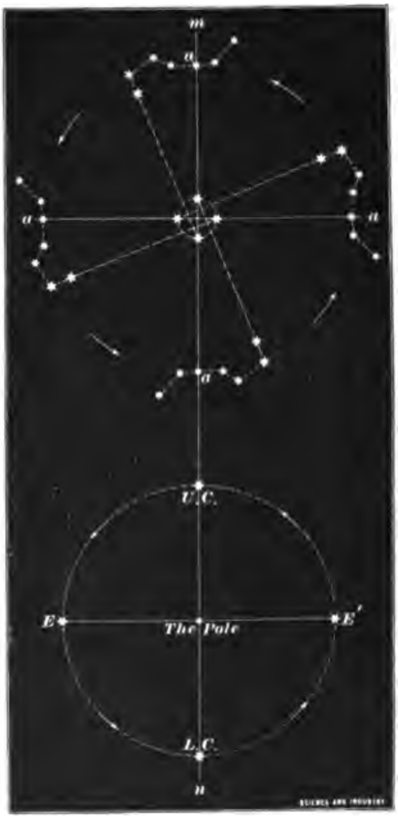
As far as the trouble with pumping hot water is concerned, any standard pump today will handle it without trouble. The only care to be taken is to have the heater and pumps so arranged that the water in the heater is higher than the pump, so as to have a head of water above the pump, two to four feet being sufficient. With these conditions, water at 210° can be pumped as easily as water at 32°.

With so many advantages and so few objections, it is no wonder that the open-type heater has secured so many supporters.

LATITUDE BY POLARIS.

Ernest K. Roden.

IN THE October, 1899, number of "The Mechanic Arts Magazine," the writer had occasion to present a few facts connected with Polaris, the most important star of the northern firmament. Among other things pointed out was that by the aid of Polaris the latitude of an observer could be determined at any time of the night by an inconsiderable amount of figuring. How this is accomplished we will endeavor to explain in the following, using language as simple as possible, at the same time assuming that the reader possesses some knowledge of the rudimentary principles of astronomy.



To commence with, the reader is referred to the lower figure of the accompanying diagram, where the center of the circle represents the celestial pole, and the dotted circle the apparent orbit of the pole star. Now, when the star is at *E* or *E'*—at its greatest western or eastern elongation—it is evident that its true altitude is equal to the altitude of the pole or equal to the latitude of the observer. To understand this it will be well to remember that the celestial pole, being 90° from the equator, will appear to an observer stationed at that great circle to be on the horizon, and to rise in direct proportion as the observer advances toward the north. At the equator the latitude is 0°, and the pole star being on the horizon, its altitude is also 0°. If the observer advanced to 20° north latitude, he would see the pole star at an altitude of 20° above his horizon, and so on at all latitudes, until 90° latitude was reached, when the star would be directly over his head, or 90° from his horizon. Hence, the true altitude of the pole star, when situated at either of the positions *E* or *E'*, would give at once the latitude of the observer. Should the altitude of the star be measured when at its upper culmination (*U. C.*), the latitude would be obtained by subtracting from the true altitude the polar distance of the star, which at present is equal to 74', nearly; if measured when at its lower culmination (*L. C.*), the polar distance added to the true altitude would be equal to the latitude of the observer.

Now, since the pole star performs its apparent daily circuit around the celestial pole in 24 hours, it follows that an interval of 6 hours is required to pass from one of the positions indicated in the diagram to the next. Consequently, at any intermediate position, a certain fraction of the polar distance will have to be added or subtracted from the true altitude, the amount of which depends on the value of the angle at the pole, subtended by a line connecting the pole with the star and the meridian *m n*; this angle is known as the *hour angle* of Polaris. A table prepared at the National Observatory and reproduced on the next page, gives the amount of correction corresponding to different values of the hour angle that is to be applied to the true altitude according to its sign.

Therefore, all an observer has to do to determine the latitude by Polaris at any time of the night is to find its hour angle at the moment of measuring the altitude; and in order to do so, he must know the local sidereal time. Having a chronometer or

other watch registering, for instance, local mean time, the sidereal time and then the hour angle is easily arrived at. The entire procedure may be embodied in the following rules:

1. Measure the altitude and note the time indicated by the timepiece.

2. Reduce the observed altitude to true altitude.

3. Reduce the recorded time of observation to local sidereal time.

according to its sign. The result is the latitude of the place to a close approximation.

The process of reducing the observed altitude to true altitude is different, and depends on what instrument is employed for measuring the altitude. In case a transit is used, a correction for refraction and possibly error of the instrument will give the true altitude; if a sextant is used in connection with the sea horizon, the true altitude is found by applying a correction

TABLE FOR 1900.

Hour Angle.	0^h	1^h	2^h	3^h	4^h	5^h
m	° ′	° ′	° ′	° ′	° ′	° ′
0	−1 13.6	−1 11.0	−1 3.5	−0 51.6	−0 36.2	−0 18.4
5	1 13.6	1 10.6	1 2.7	0 50.4	0 34.8	0 16.9
10	1 13.5	1 10.1	1 1.8	0 49.2	0 33.4	0 15.3
15	1 13.4	1 9.6	1 0.9	0 48.0	0 32.0	0 13.7
20	−1 13.3	−1 9.0	−1 0.0	−0 46.8	−0 30.5	−0 12.1
25	1 13.2	1 8.4	0 59.0	0 45.5	0 29.0	0 10.5
30	1 13.0	1 7.8	0 58.0	0 44.2	0 27.5	0 8.9
35	1 12.8	1 7.2	0 57.0	0 42.9	0 26.0	0 7.3
40	−1 12.5	−1 6.5	−0 56.0	−0 41.6	−0 24.5	−0 5.7
45	1 12.2	1 5.8	0 54.9	0 40.3	0 23.0	0 4.1
50	1 11.8	1 5.1	0 53.8	0 39.0	0 21.5	0 2.5
55	1 11.4	1 4.3	0 52.7	0 37.6	0 20.0	−0 0.9
60	−1 11.0	−1 3.5	−0 51.6	−0 36.2	−0 18.4	+0 0.8

Hour Angle.	6^h	7^h	8^h	9^h	10^h	11^h
m	° ′	° ′	° ′	° ′	° ′	° ′
0	+0 0.8	+0 19.8	+0 37.4	+0 52.4	+1 3.9	+1 11.2
5	0 2.4	0 21.4	0 38.8	0 53.5	1 4.7	1 11.6
10	0 4.0	0 22.9	0 40.1	0 54.6	1 5.4	1 12.0
15	0 5.6	0 24.4	0 41.4	0 55.7	1 6.1	1 12.3
20	+0 7.2	+0 25.9	+0 42.7	+0 56.7	+1 6.8	+1 12.6
25	0 8.8	0 27.4	0 44.0	0 57.7	1 7.5	1 12.8
30	0 10.4	0 28.9	0 45.3	0 58.7	1 8.1	1 13.0
35	0 12.0	0 30.3	0 46.6	0 59.7	1 8.7	1 13.2
40	+0 13.6	+0 31.7	+0 47.8	+1 0.6	+1 9.2	+1 13.3
45	0 15.2	0 33.1	0 49.0	1 1.5	1 9.7	1 13.4
50	0 16.8	0 34.6	0 50.2	1 2.4	1 10.2	1 13.5
55	0 18.3	0 36.0	0 51.3	1 3.2	1 10.7	1 13.6
60	+0 19.8	+0 37.4	+0 52.4	+1 3.9	+1 11.2	+1 13.6

4. If the sidereal time is less than $1^h\ 20^m$, subtract it from $1^h\ 20^m$; if it is between $1^h\ 20^m$ and $13^h\ 20^m$, subtract $1^h\ 20^m$ from it; if it is greater than $13^h\ 20^m$, subtract it from $25^h\ 20^m$. The remainder in each case is the hour angle of Polaris.

5. With this hour angle, take from the table the portion of the polar distance referred to, and apply it to the true altitude

for instrumental error, for dip of the horizon, and for refraction; if a sextant is used in connection with an artificial horizon, the instrumental error is first applied. The result divided by 2 and corrected for refraction is then the true altitude of the star. The reduction of the recorded time of observation is shown in the example given. Its execution, however, requires a knowledge of

the ordinary units of time employed in astronomy. Should the timepiece used by the observer happen to be regulated to show local sidereal time, the process of finding the hour angle would be greatly simplified; as it is, clocks and watches in ordinary use indicate local mean time.

EXAMPLE.—On September 30, 1900, at $10^h\ 30^m\ 0^s$ P. M., local mean time, in longitude 30° east of Greenwich, the altitude of Polaris, as observed by a transit, was 43° 19′ 40″, instrumental error = + 1′ 20″, refraction = 1′. Required, the latitude of the observer.

SOLUTION.—

Local mean time	=	$10^h\ 30^m\ 0^s$
Reductions from Table III N. A. for $10^h\ 30^m$	=	$+\ 1^m\ 43.5^s$
Greenwich sidereal time at mean noon, Sept. 30	=	$12^h\ 35^m\ 6.4^s$
Reduction from Table III N. A. for longitude (= 2^h east or minus)	=	$-\ 19.7^s$
Algebraic sum (= local sidereal time)	=	$23^h\ 6^m\ 30^s$
		$25^h\ 23^m\ 0^s$
Subtract L. S. T. according to rule 4	−	$23^h\ 6^m\ 30^s$
Remainder = hour angle of Polaris	=	$2^h\ 16^m\ 30^s$
Observed altitude	=	43° 19′ 40″
Instrumental error	=	+ 1′ 20″
		43° 21′
Correction for refraction	=	− 1′
True altitude	=	43° 20′
Correction from preceding table		− 1° 0.7′
Latitude	=	42° 19.3′ Ans.

The chief difficulty in using the pole star to determine latitude, the reader will find, is to measure its altitude by means of a sextant in connection with the sea horizon, the star being very small and the northern part of the horizon not well defined. However, after some practice an observer is usually able to obtain quite satisfactory results.

As to the determination of the true meridian by the pole star, the reader is referred to the upper figure of the diagram. When Alioth *a*, the third star of the handle in the constellation Great Bear, is perpendicularly above or below the pole star, the latter, as well as Alioth itself, indicates the direction of the true meridian. When Alioth and the pole star are both on the same horizontal line, the polar distance of Polaris laid off to the right or left, according to its being east or west of the celestial pole, will give the direction of the true meridian.

To determine the true meridian, for instance, by means of a transit, the time of the star's upper or lower culmination is noted from tables prepared for this purpose, and a suitable place selected for the instrument. Then, a few minutes before the indicated time of transition, the observer directs the telescope toward the star and follows it closely by moving the cross-hairs with the tangent screw. When the pole star is exactly in line with Alioth, it is evident that the line of sight will be in the true meridian.

As an interesting item connected with the pole star, it may be mentioned that quite recently Prof. W. W. Campbell, of the Lick Observatory, discovered that Polaris in reality is a triple star, or a system composed of two bodies that revolve around each other in a period of four days and at the same time move in a much wider sweep around the third body, just as the moon and the earth revolves around the sun. These separate bodies that compose the system cannot be seen with the telescope, nor is it likely that they will ever be seen by any instrument. Their existence, however, is determined by the spectroscope.

THE DRIEST PLACE ON EARTH.

PAYTA, which is situated in Peru, about five degrees south of the equator, is said to be the driest place on earth—the average interval between two showers being seven years; the latest reported shower lasted from 10 P. M. till noon next day. Most of the flora are annuals, the seeds of which remain dormant in the earth for seven years, until a shower comes to cause them to germinate. The natives maintain themselves by the cultivation of the long-rooted Peruvian cotton, which lives in the river beds for seven years without rain. The coast upon which Payta stands has risen 40 feet in historic times.

THE STREET-RAILWAY MOTOR.

R. B. Williamson.

A Short Sketch of the Development of This Type of Motor—Points in the Design of the Modern Street-Railway Motor.

THE trolley car has become such a common factor in every-day life that few of us ever stop to think that not more than ten or twelve years ago such cars were largely an experiment, and many at that time predicted that they would never become a success. There was considerable ground for such a prediction at that time, because the few cars that had been tried were frequently laid up, due to breakdowns of the motors. Previous to this, electric motors had been used quite extensively for stationary work, and had given general satisfaction. It was therefore natural that the first motors used in connection with street cars should be made in very much the same way as those used for other work, only such modifications being made as were necessary to allow of the motor being placed under the car floor and geared to the wheels. Such motors were continually giving trouble, and electrical engineers soon found out that a motor, to work successfully under the floor of a street car, must be considerably different in design to the one used for stationary work. A great deal of attention was given to perfecting the design of these motors, and from that day to this there has been steady progress along this line. Very few pieces of electrical machinery, or, in fact, any kind of machinery, have had the time and money spent on their improvement that the street-railway motor has, and the result is that today we have a piece of machinery of highly specialized design, which, considering the work it is called upon to do, performs remarkably well and gives very little trouble.

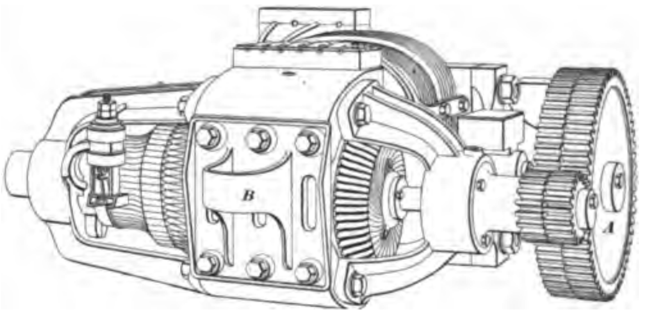


Fig. 1.

No other piece of electrical machinery is called upon to do such hard work or is subjected to such rough usage as the street-railway motor. It is liable to be struck by stones lying on the track; it must be able to run through mud and water; and, on top of all this, it is frequently forced to do several times the amount of work it was designed to do. The fact that today there are so many of these motors in operation all over the country, and that the percentage of breakdowns is so small, shows the degree of perfection to which they have been brought.

The requirements to be met in the design of these motors are far more limiting in their nature than those met with in the design of stationary motors. In the first place, the dimensions of the motor are limited by the fact that it must be placed wholly under the floor of the car; its dimensions are also limited by the gauge of the track and by the diameter of the car wheels. The motor must be practically dust- and water-tight, and it must be very strong mechanically, to withstand the shocks it is subjected to; it must be of such form that it may be easily suspended from and geared to the axle. In addition to these requirements, the motor should be light and have a fairly high electrical efficiency, though this latter requirement is generally sacrificed to some

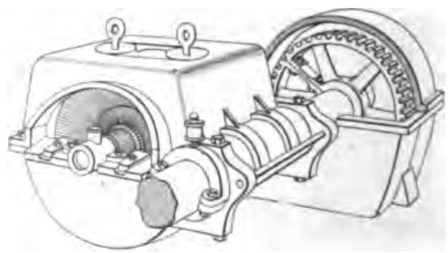


Fig. 2.

extent to secure lightness and low speed. The essential electrical parts of a street-railway motor are the same as those of any continuous-current dynamo or motor. The design of these parts is, of course, adapted to the special conditions to be met, but we always have the essential features, namely, the field-magnet frame with its windings, and the armature with its commutator, together with the necessary brushes and brush holders. All these motors are series-wound; i. e., the winding on the field is connected in series with the winding on the armature, so that all the current that flows through the armature flows also through the field. This calls for a field coil consisting of a comparatively small number of turns of heavy wire, thus giving a coil that is substantial and easily wound. To keep moisture from working into these coils they are heavily taped, and insulated with varnish and japan. The field frame is, in modern motors, made

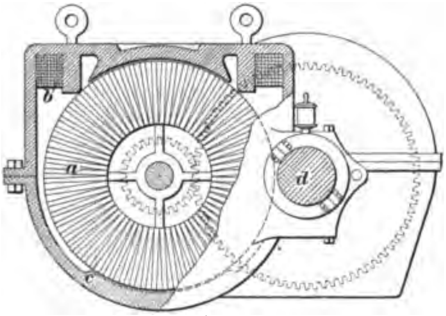


FIG. 3.

of cast steel, and is of such form as to completely enclose the armature and field windings. The armature itself is, in nearly every case, of the drum type, provided with coils sunk in slots on the circumference. Although the construction used at present is briefly as outlined, this was adopted only as the result of long and gradual development. It will be instructive, therefore, to take up briefly some of the more important motors, indicating the development of the present form from the earlier types.

All the motors used eight or ten years ago were provided with ring or drum armatures having the wire wound on the surface of a smooth core. Cast steel had not then come into use for magnet frames, because the art of making steel castings was not, at that time, far enough advanced to insure castings sound enough for this kind of work. The fields were made largely of cast iron, and consequently the magnetic field obtainable was not as strong as that obtained in the more modern machines. The smooth-core winding also necessitated a comparatively long air gap, and this also kept down the strength of the field. For these reasons

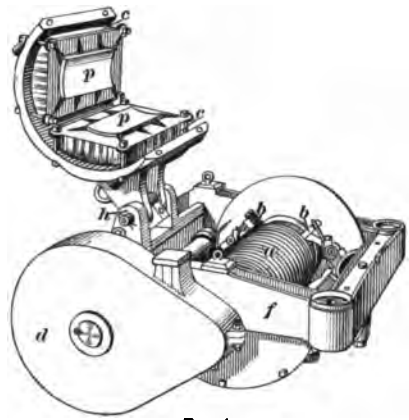


FIG. 4.

the armature of such motors had to be run at a high speed, in order to generate the required counter-electromotive force, and this speed was so high that the armature could not be geared directly to the car axle. The necessary speed reduction was accomplished by means of an intermediate shaft. This shaft carried a large gear on one end, which engaged with the armature pinion, and on the other end carried a pinion that engaged with the axle gear. On account of this double reduction in speed, such motors were commonly called *double-reduction* motors. Fig. 1 shows the Sprague No. 6 double-reduction motor. This was

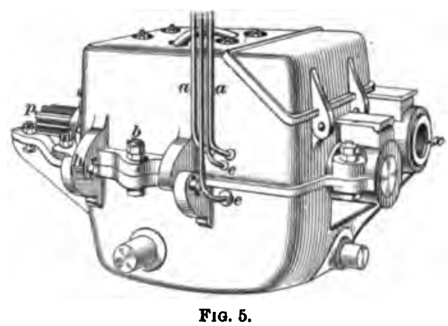


FIG. 5.

one of the most successful of the earlier forms, and did some remarkably good work; it was, in fact, the first really successful street-car motor. This motor was provided with a smooth-core armature, wound with form-wound coils. The gear of the intermediate

shaft is shown at A, the pinion on the other end being hidden. The axle passes through bearings in the back end of the field frame, and the front end is supported by the nose casting B resting on springs supported

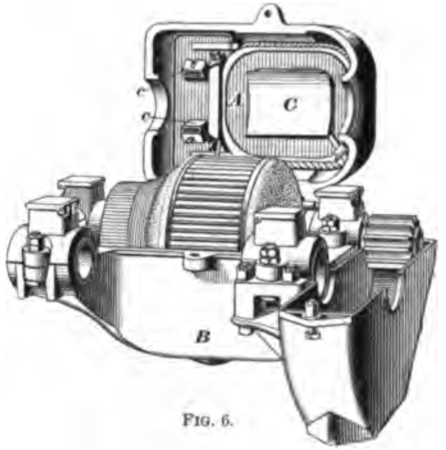


FIG. 6.

by the truck. This is the style of suspension in common use at present. It will be seen from the figure that the field coils, armature, and many other parts of this motor were considerably exposed. The gears also were exposed, and dust and dirt got into them, causing excessive wear. The double-reduction gearing was a great disadvantage, not only on account of the expense of renewals, but also on account of the large amount of noise made. Engineers, therefore, devoted their attention to bringing out a motor that would be more completely enclosed, and that would run at a speed low enough to permit connection to the axle by one pair of gears.

The motors shown in Figs. 2, 3, and 4 are some of the first single-reduction motors. That shown in Figs. 2 and 3 was brought out seven or eight years ago by The Thomson-Houston Company, and was known as the W. P. (waterproof) type. This motor was a great improvement over the old double-reduction style, and large numbers of them were used; in fact, a great many of them are in use today. A section of this motor, shown in Fig. 3, will give a fair idea of the arrangement of the parts. The armature a was of large diameter, in order to secure low speed. Cast steel was coming into use about the time this motor was brought out, and the use of this enabled stronger fields to be obtained, and thus aided in cutting down the speed. The field was of very peculiar shape, and was designed to enclose the armature and field coils as completely as possible. It was of the two-pole type, but was provided with only one field coil b placed in the upper part. The lower pole piece was simply a slight projection c on the lower casting. The gear and pinion were completely enclosed in a dust-proof case, which was kept partly full of soft grease. The armature of this motor was slotted, and this helped materially in obtaining a low speed. The axle d passed through the back of the motor, and the front was supported by a cross-bar resting on the side bars of the truck. The two halves of the field were hinged at the back, so that, by taking out the bolts, one half could be thrown back to give access to the armature.

Fig. 4 shows a Westinghouse No. 3 motor, brought out in 1891; it was the first Westinghouse single-reduction motor. This machine is of interest because it embodies many of the points still retained in the most recent motors. This motor is of the four-pole type, and is shown in the figure with the top half of the field thrown back. Two of the pole pieces p, p and the field coils c, c are shown. A cast-iron yoke surrounds the motor, and carries the axle bearings at the back. The gear-case d protects the gears from dust and dirt. This motor was made of cast iron, and was, consequently, rather heavy for its output, but it was a decided improvement on the previous types as regards being dust- and water-proof.

A still more recent type is that shown in Figs. 5 and 6. This motor was brought out by The General Electric Company, as a successor to the W. P. motor previously described. It is known as the G. E. 800, and has a capacity of 25 horsepower; it is also designed to give a drawbar pull of

FIG. 7.

800 pounds when mounted on 33-inch wheels and taking its normal full-load current. When closed, the motor has the shape of a rectangular box, and the two halves of the field completely enclose the working parts,

so that there is very little chance for dust or water to work in. A tightly closing lid on top allows access to the commutator and brush holders. This motor is of the four-pole type, but has only two field coils, one

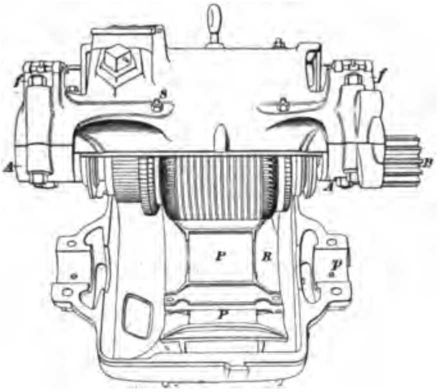


FIG. 8.

of which is shown at *A*, Fig. 6, while the other lies in the bottom of the lower half of the field. One pole piece is shown at *C*, and the pole pieces at the side are slight projections on the casting. The armature is of the toothed-drum type, and, like that of the Westinghouse motor shown in Fig. 4, it is provided with a two-circuit winding, so that only two brushes are required. This brings the two brush holders *c*, *c* on top of the commutator, where they are easily reached. This motor is extensively used, but has been replaced by a later type having four poles and four field coils. Cast steel is used throughout in the construction of these motors.

The Westinghouse 12-A type is shown in Figs. 7 and 8. This may be taken as a fair example of the modern street-railway motor, and if the reader will compare it with Fig. 1 he will get some idea of the changes that have gradually taken place. From a comparatively open construction the movement has been steadily toward the closed-in four-pole type. Single-reduction gearing is used almost exclusively, and steel is used for the field frame. Fig. 9 shows the armature of this motor. It is of the toothed type, provided with form-wound coils arranged at the ends so as to secure good ventilation. The commutator is large and has ample wearing surface. Much attention has also been paid to the design of the bearings, which, it will be noticed, do not project inside the case; the shield rings *s*, *s* on the armature are an additional safeguard to prevent grease from working into the motor. Each bearing is provided with large grease cups, the lids of which are held closed by springs. These motors are remarkably light for their output, and they will stand severe overloads for short intervals without sparking or overheating. Later motors have been brought out, but their general design is very little different from that shown. Laminated pole pieces are used in recent machines, thus reducing the heating and improving the commutation, with the result that such motors operate sparklessly under all loads.

The question may have arisen in the mind of the reader as to why motors have not been built to drive the axle directly, without the intervention of gearing. Such motors have been tried, but have never proved a success, except perhaps in some electric locomotives where the motors are of unusually large size. It has not proved practicable to build motors of the ordinary size, say 25 or 50 horsepower, that would run slow enough to have their armatures mounted directly on the axle, and at the same time be efficient and light. Such motors as were tried were very heavy, and the dead weight on the axle soon pounded out the rail joints. Machine-cut steel gears running at slow speed give very little trouble, and, if properly cared for, run quietly and consume but a small amount of power, so that the single-reduction motor has so far had nothing to fear from any of the direct-connected motors brought out; in fact, there seems, at the present time, to be no very great effort made to apply direct-connected motors to cars.

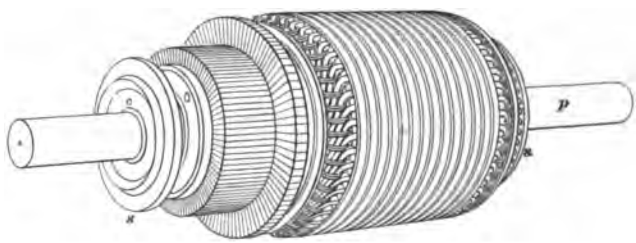


FIG. 9.

The foregoing outline shows that the street-railway motor as now built has been a gradual development from the older types. As soon as the weak points were noticed, they were remedied in the next motor, and the result is that today we have motors that

leave little to be desired. The general design of such motors has been changed comparatively little in the past two or three years, a fact that goes to show that they are, in their present form, satisfactory machines. No doubt motors will continue to be built in larger and heavier sizes, but, like the case of the locomotive, the point seems to have been reached where any further changes will be more in the size of the motor than in any radical change in the design. It may be, too, that in the course of a few years we will find the continuous-current motor largely replaced by alternating-current motors, but it is safe to say that, should such motors be put into use, their general design will follow quite closely that which has been gradually developed for the direct-current motor, and which has been made to perform such excellent work.

QUESTIONS FOR STEAM ENGINEERS.

(Continued from the December, 1899, Number.)

Chas. J. Mason.

VALUABLE PROPERTIES OF STEAM—COMBUSTION—SENSIBLE AND LATENT HEAT—TOTAL HEAT. SPECIFIC HEAT—WORK—POWER—THE MECHANICAL EQUIVALENT OF HEAT.

IN THE article of our last issue we learned that steam is invisible, and that it is elastic.

Now, if we are of an inquiring turn of mind, the following question will naturally arise:

Of what is steam composed?

We have already stated that steam is generated from *water;* so that water and steam are *one and the same* thing, but in different states. There is one other state in which water may exist—that of ice. These three states are known as the solid, liquid, and gaseous states of water. In all states, water is composed of two gases, or elements, oxygen and hydrogen, in the proportion of 8 parts of oxygen to 1 part of hydrogen, by weight; or by volume of 1 part of oxygen to 2 parts of hydrogen.

What are the properties that make steam so valuable to us?

The principal ones are the following:

Its great *expansive* power.

It is *easily condensed.*

The *small space* it occupies when condensed.

A cubic inch of water turned into steam at the pressure of the atmosphere, i. e., 14.69 pounds absolute, will *expand* into 1,646 cubic inches (roughly speaking, we say that a cubic inch of water expands into a cubic foot of steam—1,728 cubic inches—at the pressure of the atmosphere). But the same water would expand only to 841.3 cubic inches if subjected to a pressure of 30 pounds absolute; so the volume varies with the pressure. The term *volume* as here used means the space a given quantity of water will occupy when turned into steam.

The expansive power of steam is taken advantage of, in the steam engine, by cutting off the supply at a certain portion of each stroke, and allowing the balance of the stroke to be performed by the imprisoned steam in the cylinder. It is obvious that no good would result should we admit steam during the *whole* stroke, when the same amount of work could be done by cutting off at half stroke, and using the expansive force in the steam for the other half. We do not mean by the foregoing that steam cut off at half stroke in a cylinder can perform the same amount of work as when the steam is carried full stroke; but we do mean that it would be of no use to admit steam full stroke, when the work the engine has to do can be obtained by cutting off at half stroke. Engines are so constructed that the steam is cut off at a point to suit the load, no more being consumed than actually required to do the work, and thus the expansive property of steam is utilized.

It is easily condensed. What is meant by steam being easily condensed? How is it condensed? What do we condense it for? These are questions we should ask ourselves and seek the answers to. Well, let us look into them.

Steam having a temperature corresponding to that of the water from which it is formed, and a pressure corresponding to its temperature, is known as saturated steam, and is just at the point of condensation and superheating. That is, the slightest amount of heat abstracted causes some of the steam to condense into water; and the slightest amount of heat added changes the steam from the saturated state to the superheated state.

Now, as soon as the steam leaves the boiler heat is lost by radiation from the pipes conveying it to its destination, and the farther away the steam is carried, the greater the radiation of heat; hence, more steam is condensed, and consequently the pressure is lowered. Now, as the mere radiation of heat causes an appreciable condensation, it is reasonable to infer that if rapid means of abstracting the heat are provided, condensation will be equally rapid; and if these means are easily obtained, will be easily performed. After the steam has done its work in the engine, it is condensed by being brought in direct contact with cold water, or surfaces cooled by water passing over them; water being the cheapest and most easily obtained medium by which to abstract the heat.

The small space it occupies when condensed. The converse of the explanation of the expansive power of steam is applicable here. As water, when turned into steam, expands and occupies a much greater space than that originally occupied, so will the steam when condensed shrink back to the volume occupied before it was turned into steam.

Why do you condense the steam?

We know that a perfect vacuum is an *empty* space—a space void of all pressure. When the steam is condensed a partial vacuum is formed, as the pressure is decreased, and so the back pressure, which would otherwise be against the piston in an engine, is destroyed; thus we get more useful work from the steam.

While steam is very valuable to us because of the reasons cited above, it is not the source of power in the steam engine. The heat that is stored in the fuel that is consumed is the real source of all power in the engine; the steam is only an agent that possesses valuable and convenient properties for applying the energy of the heat to the engine.

How is the heat liberated from the fuel in which it was originally stored?

Simply by burning it. Coal is composed chiefly of the following elements: Carbon, hydrogen, nitrogen, oxygen, and sulphur. When these elements combine chemically with a certain quantity of oxygen, combustion takes place, accompanied by light and heat. The products of perfect combustion are water, nitrogen, and carbonic acid, and to assure these products, a high temperature and a sufficient supply of oxygen are necessary. It has been stated by those that have made a special study of the subject, that in actual practice it requires about 300 cubic feet of air for the combustion of 1 pound of coal. Air is composed of two gases, nitrogen and oxygen, mixed mechanically, in the proportion of 79 parts of nitrogen to 21 parts of oxygen, by volume. The oxygen of the air combines with the carbon and the hydrogen of the coal, and the heat liberated in the process turns the water in the boiler into steam.

How many forms of heat are there?

Heat has been defined as a mode of motion. It has also been stated that the source of all power in the steam engine is the heat stored in the coal. Now, there are two forms of heat, namely, *sensible* heat and *latent* heat. We will try to explain just what the terms mean.

Sensible heat is that heat which affects the thermometer. Latent heat is that heat which does not affect the thermometer. In order to cause a body to pass from the solid to the liquid state, and from the liquid to the gaseous, heat must be applied and stored up in the body. This heat is known as latent heat, and being stored up in the body, so to speak, must be abstracted to change the body back to its former state. This means that the latent heat can be recovered. To explain this further, we will quote a reliable authority:

"Take a pailful of powdered ice and bring it into a room in which is a large fire; put a thermometer into the pail with the ice, and when the latter begins to melt, the former will stand at 32°, and as long as there is any ice to melt it will remain at that point, notwithstanding the heat of the room. Now, there must be a large amount of heat entering the water, since the ice begins to melt, but it has no effect on the thermometer, and this heat that has so entered is called the *latent heat of water*.

"But, the instant the last bit of ice is melted, the thermometer will begin to rise, and will continue to rise till the water boils, when it will stand at 212° Fahrenheit; but, although the water goes on receiving heat after this, the instrument will stand at 212° until the water is all boiled away. The heat that enters the water from boiling till it becomes steam is called the *latent heat of steam.*"

In short, the latent heat of steam is the amount of heat required to convert 1 pound of water, at a given temperature, into steam at the same temperature. The total heat of evaporation is the sum of the latent heat and sensible heat above 32°, and is the quantity of heat required to raise 1 pound of water from 32° Fahrenheit to the

temperature of evaporation, and to convert it into steam at that temperature. Hence, to obtain the total heat, subtract 32 from the sensible heat in degrees Fahrenheit, and add the remainder to the latent heat, which is given in British thermal units. Owing to the fact that the specific heat of water varies somewhat at different temperatures, the sensible heat diminished by 32° does not represent the exact amount of heat required to raise 1 pound of water from the freezing point to the boiling point. The difference is so slight, however, that it may be safely neglected in practical work.

The following table will show the relation existing between the different columns, and will serve as food for thought:

Absolute Pressure. Pounds.	Sensible Heat.	Latent Heat.	Total Heat.	Relative Volume.
15	212	966	1,146	1,646
30	251	939	1,158	841
45	275	923	1,165	575
60	293	910	1,171	439

It will be seen from the above table that the sensible heat increases with the pressure, while the latent heat decreases. It will also be seen that the total heat varies but little.

In the "Relative Volume" column it will be noticed that as the pressure rises the volume becomes smaller; for example, at 15 pounds pressure above vacuum (otherwise called 1 atmosphere) the volume is 1,646. As explained previously, this means that a given quantity of water, when turned into steam at the given pressure (15 pounds), expands and occupies the given amount of space—1,646 times that of the original water.

What is meant by "specific heat"?

The specific heat of a body is the ratio between the quantity of heat required to warm that body 1°, and the quantity of heat required to warm an equal weight of water 1°.

It should be remembered that there is a difference between the temperature of a body and the quantity of heat in the body. The temperature indicates how hot or how cold the body is, or the intensity of the heat therein. If a portion of water is taken out of a vessel, the temperature is the same throughout, but the quantity of heat varies directly as the weight of water in each vessel. The temperature of a body is indicated by an instrument known as a thermometer, which consists of a glass tube of very fine bore, and having a small bulb at the bottom that contains a quantity of mercury. If the thermometer is warmed, the mercury will expand—rise up in the tube—and occupy a larger volume; if the thermometer is cooled, the column of mercury will contract—fall in the tube. A graduated scale is affixed that shows the slightest change of temperature by the rise or fall of the mercury within the tube.

Quantities of heat are measured by the unit of heat, which is relatively the same as the inch or the foot used in measuring distances, or the pound to measure weight. The unit of heat is the amount of heat necessary to raise the temperature of 1 pound of distilled water from 62° to 63° Fahrenheit, and this quantity of heat is technically known as the *British thermal unit.*

There is an exact relation between the unit of heat and the unit of work, hence the following question:

What is the unit of work, and what relation does it bear to the unit of heat?

To many, the terms "unit of heat" and "unit of work" are new, and may not be looked on with any interest. Some may even ask what these and some other phrases that have been used have to do with a man in the engine room. It can only be said in reply that as these subjects are some of the elements of the engineering profession, it is of great importance that they should be correctly understood. After a student has once gained possession of such facts as these, a new light, so to speak, is shed upon his surroundings. He sees and understands more clearly, and, what is more, his calculations and conclusions will now be based on correct fundamental principles.

How often do we hear a question like this asked, How much power will it take to move such and such a thing? when in reality, the person asking such question means to ask, What force will it take to move it? Had the person asking such a question understood the difference between force and power, he would not have used the wrong term. This is only one example of terms being incorrectly used. Even should a correct answer be given to a man that does not really understand what he wants to know, it would not be fully understood by him, for his thinking powers have not been trained along the right lines, and hence his mind is not in a condition to receive what he asks for. We do not mean to say that such a man cannot learn; on the contrary, he will be just the one that can and will learn, if he begins at the beginning. Do not think anything too

small, too elementary, to bother with, for you will surely find, as you go through life, and problems present themselves for solution, that sooner or later you will be obliged to go back and make a study of the things that at one time you thought of no consequence.

And now to the question—what is the unit of work?

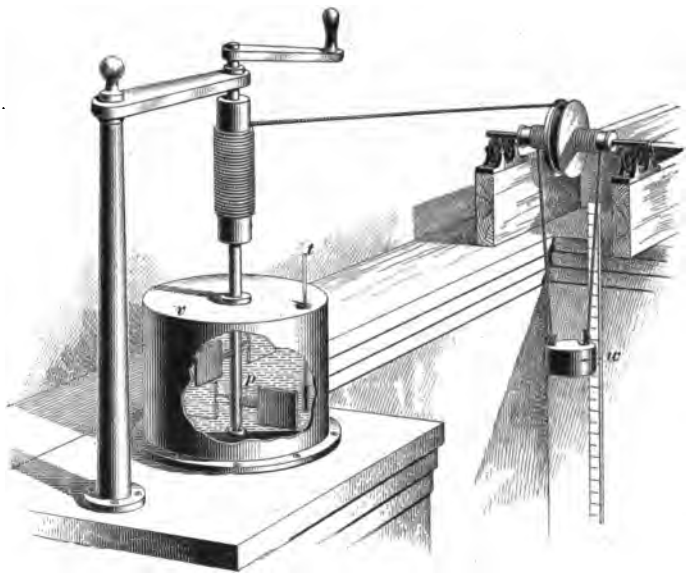
By the term work is meant the overcoming of a resistance through a space. The amount of work done is measured by the resistance overcome multiplied by the distance through which it is overcome; the resistance is measured in pounds, the distance in feet. Therefore, work is measured by the product of pounds and feet. If a body weighing 10 pounds is lifted through a height of 5 feet, then the resistance, namely, 10 pounds, multiplied by the distance through which it is overcome, namely, 5 feet, is equal to $10 \times 5 = 50$ foot-pounds of work. The unit of work is the work done in raising 1 pound through a vertical height of 1 foot, and is called the foot-pound.

Now, the unit of work has no reference to the time taken, for the same amount of work is done in lifting the weight, whether it is done in one minute or in one day; and herein is the difference between force and power, previously alluded to. The power of a machine is measured by the rate at which it can do work, and depends on the amount of work done in the unit of time. Force is that which overcomes resistance. Using the above example—a force of 10 pounds overcame the resistance due to the weight, and acted through a space of 5 feet, doing, therefore, $10 \times 5 = 50$ foot-pounds of work.

We can now consider the question of the relation between the unit of heat and the unit of work. Dr. Joule determined by experiment that 1 pound of water was increased in temperature 1° by the work done on it during the descent of 772 pounds through 1 foot.

The accompanying illustration will give an idea of the apparatus used by Dr. Joule to determine the relation between heat and work.

By an arrangement of drums and pulleys, the weight *w* in falling was made to operate the paddles *p* in the vessel *v*, which was filled with water. The work performed by the weight in falling was all expended in churning the water, except the small quantity used in overcoming the friction of the moving parts. A very delicate thermometer *t* showed that the action of the paddles raised the temperature of the water, and, since no heat was applied to the water in any way, showed that the rise in temperature was directly due to a transformation of work into heat. It was also observed that the rise in temperature was proportional to the work done. A number of careful experiments led Dr. Joule to conclude that 1 British thermal unit was equivalent to 772 foot-pounds of work. Hirn, the noted German engineer, by a different method, fixed that value at 774.5 foot-pounds. Finally, Professor Rowland, of Baltimore, using an apparatus similar to Dr. Joule's, but much larger, obtained the value of 778 foot-pounds as the most probable value of the mechanical equivalent. Many textbooks still give the value of 772 foot-pounds, but nearly all modern works on the subject of heat give the value determined by Professor Rowland, which is generally used by engineers today.



CONSTRUCTION OF A GALVANIZED-IRON CORNICE.

(*Concluded from the July, 1899, Number of "The Building Trades Magazine."*)

William Neubecker.

FINISHING DETAILS—BREAKING, SOLDERING, AND BRACING THE CORNICE—SHIPPING AND ERECTING.

THE next step in the construction of the cornice under consideration is to get out the sink strip for the scroll in the side of the modillion, as shown at *a* in Fig. 17. The scroll is to be raised ¾ inch at *a*, and is to die out at *b* and *d*. The form, or the pattern, of the sink strip to accomplish this may be obtained by drawing any line, as *b d*, Fig. 18, which is equal in length to the stretchout required to go from *b* to *d*, in Fig. 17. At *a*, erect a line ¾ inch high, and draw freehand a curved line, as shown by *d c b*, and the figure will be the required pattern, 16 of which are wanted. When the sink strips have been cut out, they are rolled right and left, care being taken to solder the straight side *b a d* to the curve *d e b*, shown in Fig. 17. The amount of material required for the face of the modillion is obtained in a manner described in connection with the bracket, or end block, and the caps are soldered to the modillions after they are set up.

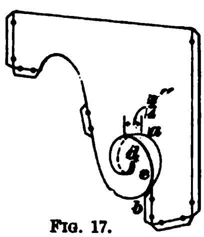


FIG. 17.

Our attention must now be directed to getting out the raised circular box, or patera, placed between the modillions, as shown at *a*, Fig. 2, in the June, 1899, issue of "The Building Trades Magazine." The pateræ are 6 inches in diameter and may be laid out from scrap pieces of metal by describing nine circles 6 inches in diameter. These will be "stripped" by soldering to them metal strips cut in the squaring shears to the required width. The pressed-zinc ornament for the panel *c*, Fig. 2, is selected from the catalogues of manufacturers of this work, and can be obtained from them at reasonable prices.

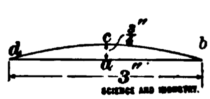


FIG. 18.

The brackets, modillions, and raised circular boxes are now finished, and the work in sequence is to get out the moldings. As the cornice is provided with end brackets projecting beyond the principal surfaces of the cornice, no miters will be required, as the moldings will butt against the side face of the brackets. Take narrow strips, say ½ inch wide, of galvanized iron, and, using the pliers in a manner similar to that described when obtaining the stretchout of the bracket, determine the amount of material required for the entire cornice. Of course, this cannot be obtained in one piece, and, for convenience in just such a case as this, various

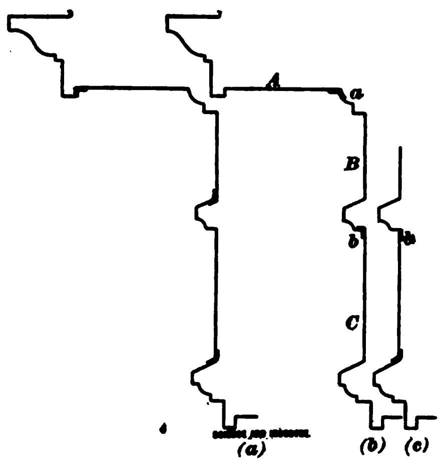


FIG. 19.

widths of galvanized iron are kept in stock. Therefore, while determining the stretchout of the cornice, cut narrow strips in lengths equal to the width of iron in stock; then it will be an easy matter to find where the seams would come, using this or that width. As a rule, seams should always be placed where they are not likely to be seen, and bent in such a manner as to avoid buckles of the metal. In Fig. 19, at (*a*), (*b*), and (*c*), are shown the several methods of placing seams in the cornice under construction. It is never good practice, under any circumstances, to make a seam as shown

at *b* in Fig. 19 (*c*); for, when soldering, the entire length will be wavy and full of buckles. The proper way to form such a seam is to bend a small edge, as shown at *b*, Fig. 19 (*b*); this takes out the buckles, and

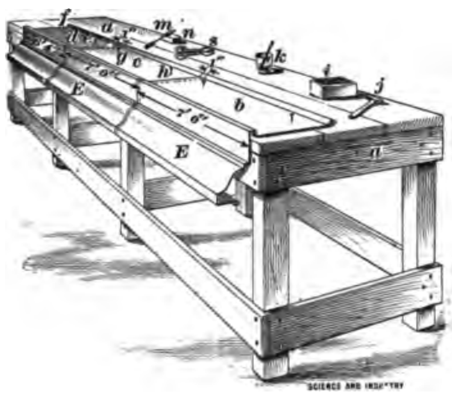


FIG. 20.

the seam can be soldered either inside or outside. In order to obtain the required length of the sheets making up the cornice, refer to Fig. 1, June, 1899, issue of "The Building Trades Magazine," from which it is found that the cornice is 20 feet in length. As the iron in stock is 7 feet long, it will

FIG. 21.

require three sheets to make up the length; two of them will be full length and one will be 6 feet 4 inches. The length is figured as follows:

Length of cornice	20 ft. 0 in.
Length of two end laps	2 in.
Length of two center laps	2 in.
Total length	20 ft. 4 in.
Length of two full sheets	14 ft. 0 in.
Length of third sheet	6 ft. 4 in.

The allowance for laps in the above calculation gives a 1-inch lap at each end and 1-inch laps at the two middle seams. The sheets are now dotted in the manner previously described, after which they are formed in the 7-foot cornice brake.

There are various forms of cornice brakes, and it requires a little experience to know how to operate one to the best advantage; however, the writer has found, during his experience of 22 years in the trade, that the whole secret of forming is not to make the second bend until the first is accurately formed.

The molding being accurately formed after

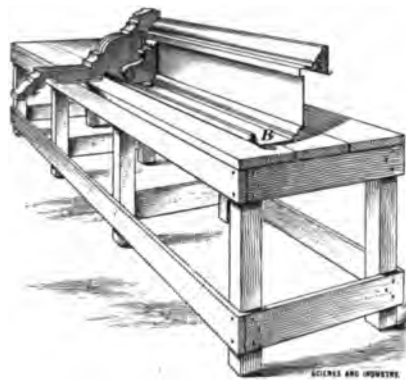


FIG. 22.

the profiles shown, the next step is to put it together in one length. Assume that it best answers the purpose to make the cornice as shown at *A B C* in Fig. 19.

The method of setting a molding together on the bench, and the tools required for the

FIG. 23.

work, are shown in Fig. 20. In this figure, *a* represents the bench, *b*, *c*, and *d* the two full sheets and the short piece forming the molding. Commence with the piece *d* and tack it to the bench with 1-inch roofing

nails, as shown at *f* and *e*. Then place sheet *c* over sheet *d*, allowing a 1-inch seam, and tack the sheet to the bench at *g*; sight the outer line of the sheets *c* and *d*, and, if perfectly straight, nail it at *h*. Perform the same operation in connection with sheet *b*. As the cornice is 20 feet long, the distance from end to end of the molding should measure 20 feet 2 inches; this allows for the two end laps. In the illustration, *i*, *j*, *k*, *m*, *n*, and *s* represent, respectively, the nail box, hammer, acid cup and brush, soldering copper, iron block, and shears, these being the tools that are always used.

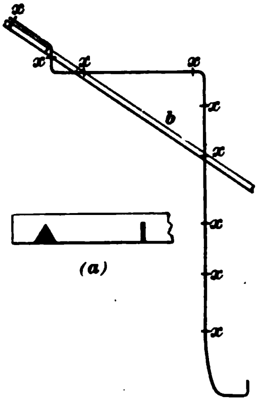


FIG. 24.

When these seams have been soldered, lift the molding carefully and let the portion that now lies on the bench hang over the other side, thus allowing *E E* to lie on the bench. In this manner all the members are soldered; after this they are riveted and the rivet heads soaked with solder. When the crowning member *A*, Fig. 19, is completed, set the moldings *B* and *C*, Fig. 19 (*b*), together in the same manner.

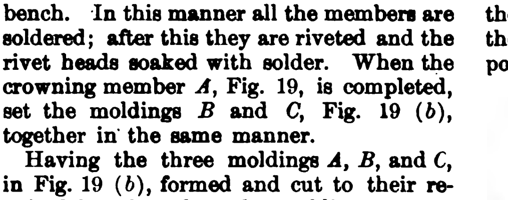


FIG. 25.

Having the three moldings *A*, *B*, and *C*, in Fig. 19 (*b*), formed and cut to their required lengths, place the molding *A* upon the bench, as shown in Fig. 21, and over it set the molding *B*, soldering it in place. Notch the two ends of the moldings, and with the pliers bend all laps toward the inside. Everything is now ready to set or solder on the end brackets, the molding shown in Fig. 21 fitting against the inside cut of the bracket, as shown in Fig. 11, July, 1899, issue of "The Building Trades Magazine." When the two end blocks are in position, mark off divisions on the molding so as to equally space the eight modillions. To obtain these divisions, proceed as follows:

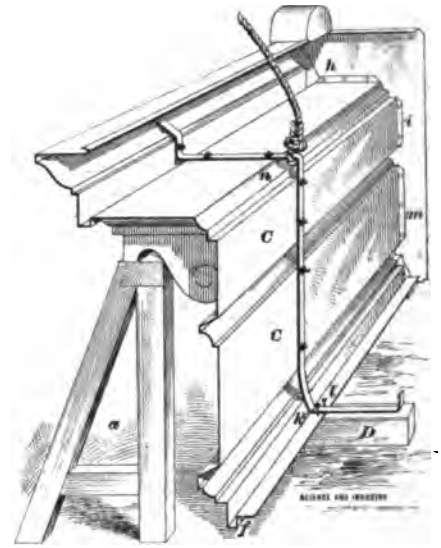


FIG. 26.

From the length of the cornice, 20 feet, deduct the width of the two end brackets, or 20 inches; this leaves 18 feet 4 inches; 8 modillions, at 6 inches each, equal 48 inches, or 4 feet, which is deducted from 18 feet 4 inches, and leaves 14 feet 4 inches, or 172 inches; dividing by 9, the number of spaces in the cornice, each space between the modillions is found to be 19⅛ inches. Place the modillions on these divisions, and solder and rivet them well in place, by means of the laps that were left on the sides. Turn the cornice over on the bench so that the portion *B*, Fig. 21, will rest as shown in Fig. 22, and in this position the raised circular boxes, located between the modillions, can be soldered in place.

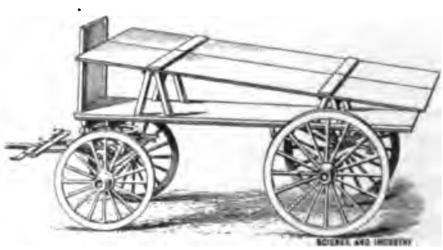


FIG. 27.

Having proceeded thus far, place the

members *B* and *C* of the cornice in position on the bench and solder the long seam marked *a*, Fig. 23. This being completed, the brackets may be fastened to the lower

FIG. 28.

molding *C* and the zinc ornaments soldered in place.

It is next required to put in the wrought-iron braces, or lookouts, which should be placed about 4 feet apart. The making of these braces is a simple matter. If soft band iron is used, the braces can be bent cold; if the iron is hard, they are apt to break. It is necessary, in laying out these braces, to refer to the detail drawing, Fig. 2, which shows the several bends in the braces

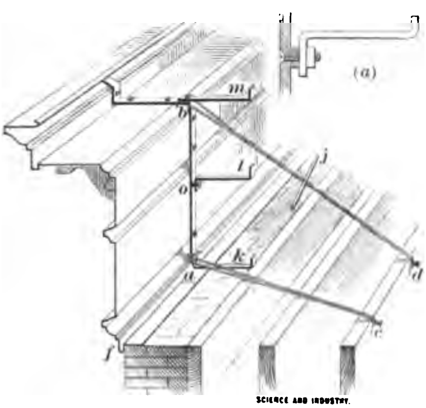


FIG. 29.

and the bolt holes marked *x*, from which the length of iron required to form the brace in one piece may be obtained.

Select a narrow strip of metal about ½ inch wide, and mark upon it the lengths of the several bends and the position of the holes required in the brace, as indicated in Fig. 24 (*b*). Straighten out the sheet-metal strip *b*, with the bolt holes and the bends for each straight section of the brace marked

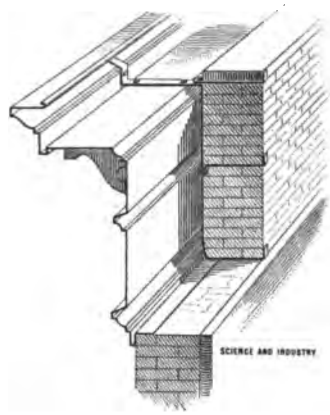


FIG. 30.

thereon. It is convenient to indicate the bolt holes by a V notch, and the bends by an I notch, as illustrated at (*a*), Fig. 24.

Having obtained the layout of the brace on the metal strip in this manner, it is employed as shown in Fig. 25, in which *a*, *b*, *c*, *d*, and *e* represent five pieces of band iron cut on the band-iron cutter. Lay the five braces closely together—placed apart on the sketch in order to show more clearly—having the ends at right angles; take the sheet-metal strip *f*, place it against the brace *a*, and mark off with slate pencil the holes and bends *g*, *h*, *i*, *j*, *k*, etc. In the same

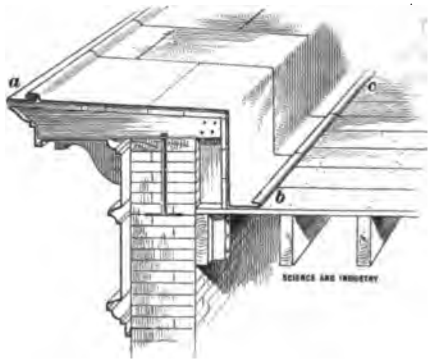


FIG. 31.

manner, take the strip and place it as shown at *l*, marking the holes and bends on the brace *e*; remove the metal strip, and with a straightedge draw lines across the pieces of band iron, crossing those that are to be punched. Do all the punching on the ½-inch

punch machine first, and make the bends on the brace bender to suit the profile of the brace.

The cornice is now taken from the bench and placed on wooden horses, a section of which is shown at *a*, Fig. 26, so that the modillions rest upon them. The five braces are now divided equally between the two end brackets, after which they are bolted in position as shown. When putting in the braces, they are pressed firmly against the galvanized-iron cornice; then with prick punch and hammer a slight impression is made on the galvanized iron through the hole in the brace. The helper on the opposite side of the cornice now places his prick punch against the impression on the sheet iron, and with the hammer drives the punch into the hole through the brace, which is held firmly in position by means of the hammer handle. By working in this manner the burr of the sheet iron works itself tightly around the hole in the brace. Through the holes formed in this manner the braces are bolted in place, the bolts being provided with a washer and the nuts then being screwed on from the inside of the cornice.

When the braces are all fastened in this manner, obtain three pieces of joist or planking, as at *D*, a little thicker than the depth of the drip *f*, and secure them under the foot of the brace with two roofing nails, as shown at *k* and *l*, Fig. 26. The laps on the end of the cornice are riveted against the end brackets, as shown at *h*, *i*, and *m*. Now look over the cornice well, and solder all nail holes; it is then ready to put in place on the building.

When loading cornices, a special rack is prepared on which to transport the cornice. It consists, as shown in Fig. 27, of two horses the width of the wagon, the front horse being higher than the rear. On top of the horses a platform is laid, provided with clamps to prevent it from slipping off the horses. The platform is one full length of 16 feet, and made in two sections in width. The cornice is now loaded upon the wagon, and the portion *C*, shown in Fig. 26, laid on the platform. The derrick employed to hoist the cornice is shown in Fig. 28; the spikes at *a* and *b* are set in the center of the roof beam, and the guy ropes *c* and *d* are fastened to a beam farther away. The hoisting rope is wound around the crank-shaft *e* when the winch is turned. It is necessary to fasten guide ropes at each end of the cornice while hoisting. The end of the hoisting rope is fastened to the angle of the brace *n*, as shown in Fig. 26.

In placing the cornice on the wall, it is secured temporarily by means of ⅛-inch wire to the brace at *a* and *b*, as shown in Fig. 29. The drip *f* of the foot-mold is drawn tight against the wall, and the wires from *a* and *b* are secured to the roof beam at *c* and *d*. The cornice can be plumbed by inserting the piece of bar iron *j* in the loop of the wire and then twisting it until the cornice is vertical. When the cornice is properly set, bolt on the anchors *k*, *l*, and *m*, and in bolting on the anchor *l* do not loosen the nut at *o*, but always provide a longer bolt at this place, furnished with two nuts, and secure the anchor as shown at (*a*), Fig. 29.

When the anchors are in place and the cornice plumb, the mason runs up his wall, as shown in Fig. 30, which holds the cornice in position.

After the wall is run up, the framer sets his wooden brackets as in Fig. 31, and planks the roof of the cornice, after which the tin roofer covers the roof with tin plate, locking it into the lock of the crown mold at *a* and soldering; also flashing out on the flat roof at *b* and *c*.

OUTPUT OF MINERALS IN GREAT BRITAIN.

FROM a Blue Book recently issued by the British government we learn that the total value of all mineral products of the British Isles in 1898 exceeded £77,000,000, showing an increase of £5,000,000 over the previous year. More than 200,000,000 tons of coal were mined, and 36,500,000 tons were exported. Careful estimates show that in fifty years England will begin to feel very severely the scarcity of cheap coal. The Blue Book referred to says: "We are already dependent upon foreign countries for much of our iron ore, and it will be an evil day when we feel the pinch of poverty in coal. The husbanding of the coal resources of the kingdom is therefore a question of national importance." Great Britain still claims the first place among coal-producing countries.

A GREAT DISCOVERY.

George McC. Robson, M. A.

CORRECTION OF KEPLER'S THIRD LAW—PROBLEM OF THE THREE BODIES—FOUNDING OF GREENWICH OBSERVATORY—NEWS FROM A FAR LAND.

When Newton saw an apple fall, he found
In that slight startle from his contemplation—
'Tis said (for I'll not answer above ground
For any sage's creed or calculation)—
A mode of proving that the earth turn'd round
In a most natural whirl, called gravitation;
And this is the sole mortal who could grapple,
Since Adam, with a fall, or with an apple.
—*Byron.*

In the third section of the Principia, Newton investigates the motion of a body describing a conic section under the action of a central force directed toward one focus. He proves that the central force must vary inversely as the square of the distance. Conversely, he proves that if a body is projected in any way and is acted on by a central force varying inversely as the square of the distance, it must describe a conic having the center of force as one of its foci—whether this conic will be an ellipse, a hyperbola, or a parabola depends on the magnitude and direction of the velocity of projection and the distance of the point of projection from the center of force. He further shows that if several bodies revolve in ellipses about the same center of force and the force varies according to the law of the inverse square of the distance, or the law of nature as it is often called, the bodies must conform to Kepler's third law. In two of the corollaries to the seventeenth proposition, he indicates a method by which the effects of disturbing forces may be estimated; the modern treatment of this subject is based on Lagrange's epoch-making paper in the "Berlin Memoirs" for 1786, and we have the authority of Laplace for the statement that Lagrange's investigations were suggested by these corollaries.

The demonstrations of these propositions are necessarily mathematical, and can be followed only by those that have a competent knowledge of the geometry of conics. It is possible, however, to indicate the spirit that underlies Newton's method. In the first place, if the path of a body is not a straight line, its deflection from a straight path is evidence that it is under the influence of some force; and the greater the amount of the deflection in a given time, the greater must be the intensity of the force. Now, deflection from a straight line is only another name for curvature; and any curve is defined by the particular law according to which its curvature varies; for example, a circle is defined by the law that its curvature is the same at all points. The law of variation of the deflecting force can be determined, therefore, if the direction of the deflecting force and the law of curvature of the path are both known. The law of curvature of a conic section can be determined mathematically and can be expressed either in geometrical or in algebraic symbols; the law of curvature determines the amount of deflection from the tangent toward the focus; and, by the laws of motion, the intensity of a force causing deflection in its own direction is proportional to the deflection; hence, the law of force under which a body describes a conic having the center of force for one of its foci can be expressed either geometrically or algebraically. The velocity at any point of the path is readily found from the law of the equable description of areas, which had been established in the second section for all central forces.

The next two sections of the Principia relate entirely to the geometry of conics. In the sixth section, Newton again takes up the motion of a body in a conic, and shows how to determine the position of the body at any time. From the law of the equable description of areas, it follows that the problem of determining the position, at a given time, of a body moving in an elliptic orbit, depends on the solution of the following geometrical problem: To find the position of a right line through a focus of an ellipse, such that the area of the sector enclosed between this line and the axis of the ellipse shall be in a given ratio to the whole area of the ellipse. This

is known as *Kepler's problem*, and is of importance in astronomy, because its solution is necessary for the determination of the place a planet will occupy in its orbit at any given time. To this problem Newton has prefixed the following lemma: "There is no oval curve such that the sectorial area cut from it by arbitrary lines can be expressed by an equation involving only a finite number of terms." Newton was dissatisfied with his proof of this lemma, and it has since been pointed out that there is a family of ovals for which it is not true; but the statement in the lemma is true for an ellipse; it follows, therefore, that Kepler's problem cannot be solved by any geometrical construction that can be effected by means of straight lines and circles. Newton gives a geometrical solution that requires the construction of a cycloid; but, on account of the difficulty of constructing this curve, he adds two arithmetical methods of approximating to the sectorial area as closely as may be desired.

The seventh section treats of the motion of a body in a straight line under the action of a central force directed toward a fixed point in the line. The eighth section discusses the orbits described by bodies under the action of a central force varying according to any law. The treatment of these problems by Newtonian methods is very involved and difficult, and does not compare favorably with modern analytical methods.

In the ninth section he treats of the motion of a body in an orbit that is revolving in its own plane about the center of force, and discusses in detail the motion of the apse line in an orbit that is nearly circular. The position of a moving body when at its greatest or its least distance from the center of force is called an *apse*, and the line joining an apse to the center of force is called an *apse line*. An elliptic orbit described about a center of force in a focus has but two apsides, and the line joining them is the major axis of the ellipse. The motion of the apse line in a planetary orbit is, therefore, the same problem as the motion of the aphelion which is illustrated by the instructive experiment of Horrox described in the October, 1899, number of "The Mechanic Arts Magazine." In a corollary, he shows how the law of force may be found from the motion of the apse line; and in another corollary he gives a method of computing the motion of the apse line due to the addition of an extraneous force to the central force. To illustrate this second corollary, he supposes a case in which the extraneous force is to the central force in the ratio of 100 to 35,745, and calculates that in such a case the progressive motion would amount to 1° 31′ 28″ per annum. In the third edition of the Principia there was added to this corollary the statement: "The apsis of the moon is about twice as swift." Thus, it would appear that Newton's theory gave the motion of the lunar apse line as 1½° per annum; whereas we know, from observation, that it is 3°. For a long period this discrepancy was the greatest obstacle to the acceptance of the theory of gravitation. Many eminent mathematicians repeated the calculations and obtained the same result. So great was the effect in shaking confidence in the exactitude of the law of gravitation that Clairaut suggested, in 1750, that the law of the inverse square might be only a first approximation, and that it would be more correct to assume the law of variation of the force to be given by some such function as $\frac{a}{r^2} + \frac{b}{r^4}$. In tracing the consequences of this suggestion, Clairaut was led to repeat the calculation on the assumption of a force varying inversely as the square of the distance, and by taking account of terms neglected in his former work he found that the law of the inverse square gave a result that agreed exactly with that obtained by observation. Some years ago, Prof. J. C. Adams, in examining Newton's papers now in the Duke of Portsmouth's collection, found a manuscript in which Newton had himself repeated his calculation on this point, taking account of the neglected terms, and obtained the correct result fifty years before the date of Clairaut's investigation. This is no solitary instance, but rather an example of many instances in which apparent exceptions to the law of gravitation have, when rightly understood, afforded strong confirmation of its exactitude and universality, and difficulties that appeared insurmountable have proved to be new occasions of triumph.

Other lunar and planetary irregularities are also treated of in the ninth section; but the exceeding brevity and conciseness of the discussion detract very much from its value. Even so eminent a mathematician as Laplace failed to find much in it on the first reading, but in the last volume of his *Mecanique Céleste*, Laplace says that on more careful reading he has no hesitation in regarding this discussion as among the most profound parts of Newton's work.

The motion of bodies on given surfaces, with special reference to the vibration of pendulums, is considered in the tenth section. In the treatment of pendulums, Newton is led to investigate the principal properties of cycloids, epicycloids, and hypocycloids.

The motion of bodies under their mutual attractions is taken into consideration, for the first time, in the eleventh section. In an introductory note, Newton remarks that the preceding propositions relate to the motions of bodies attracted to fixed centers, though it is probable that there is no such thing in nature as a fixed center. For attractions are always toward bodies, and the actions of the attracted and the attracting body are always equal and opposite, by the third law of motion; so that, if there are two bodies, neither the attracted nor the attracting body is truly at rest, but both revolve round their common center of gravity. Then follows a warning that when he uses the word *attraction* in the following propositions he is merely using a familiar word in its common sense, and that the use of this word does not imply any theory as to the nature or cause of the attraction. In spite of this warning and of many other passages of similar import in his writings, it has frequently been declared that Newton demonstrated attraction as a physical cause. On this point Professor De Morgan says: "The word *attraction*, as used by Newton, only means a *drawing towards*, without any implication as to the cause, and whether he said that matter attracts matter, or young lady attracts young gentleman, he was using one word in one sense. Newton found the law of the first to be the inverse square of the distance: I am not aware that the law of the second has yet been discovered."

If two bodies S and P attract each other with a force varying according to any law, and are not influenced by any other force, the two bodies will describe orbits about a point C, which is the center of gravity of the system composed of S and P, the center of gravity C being either at rest or in uniform motion in a straight line. To determine the relative motion of the two bodies, we may regard either of them as fixed; then the other body will describe, about the one regarded as fixed, an orbit similar to that described by each about their center of gravity. Newton shows that if the mutual attraction of the bodies acts according to the law of nature, these orbits are conics; and conversely, if the orbits are conics, the attractive force must act according to the law of nature.

In the fifty-ninth proposition he goes on to show that the periodic time T in which the bodies S and P describe their orbits about their center of gravity C, is to the periodic time in which P would revolve about S, if S were fixed in the ratio $\sqrt{CP} : \sqrt{SP}$. Let M_s and M_p denote the masses of the two bodies. If the two bodies S and P were attached to the ends of a uniform bar equal in length to the distance SP, we know that the whole system would balance about the point C; hence, from the elementary principles of the lever,

$$CP : SP = M_s : M_s + M_p; \qquad (1)$$

whence, $T : t = \sqrt{M_s} : \sqrt{M_s + M_p}. \qquad (2)$

It will be observed that this demonstration involves no assumption as to the way in which the mutual attraction of the two bodies is related to their masses, nor does it even involve an assumption as to the law according to which the attraction between two given bodies varies with the distance; the relation between the periodic times expressed by equation (2) is true for any law of force. Newton had not yet reached the consideration of the relation between the masses of bodies and their mutual attraction. Now, suppose the body P is removed and replaced by a body P', whose mass is $M_{p'}$, and for which the periodic times are T' and t'; equation (2), when applied to this body, becomes,

$$T' : t' = \sqrt{M_s} : \sqrt{M_s + M_{p'}}. \qquad (3)$$

Here, t and t' are the periodic times in which P and P', respectively, would describe orbits about S, if S were fixed. If the force varies according to the law of nature, and if d and d' are the mean distances of the bodies P and P' from S, from the third section of the Principia, we have

$$\left(\frac{t}{t'}\right)^2 = \left(\frac{d}{d'}\right)^3. \qquad (4)$$

From equations (2) and (3), we readily obtain

$$\left(\frac{T}{T'}\right)^2 = \left(\frac{t}{t'}\right)^2 \frac{M_s + M_{p'}}{M + M_p}. \qquad (5)$$

Substituting $\left(\frac{d}{d'}\right)^3$ for $\left(\frac{t}{t'}\right)^2$ in equation (5), we have

$$\left(\frac{T}{T'}\right)^2 = \left(\frac{d}{d'}\right)^3 \frac{M_s + M_{p'}}{M_s + M_p}. \qquad (6)$$

If S is the sun and P and P' are two planets, then equation (6) shows that Kepler's third law is not exactly true; but it will be very nearly true if the mass of the sun is very great compared with the mass of

any of the planets. Observation shows that Kepler's third law is very nearly true for all the planets, and, therefore, we conclude that the mass of the sun is very much greater than the mass of any planet. As a matter of fact, the mass of the largest planet, Jupiter, is less than a thousandth part of that of the sun. The correction of Kepler's law expressed in equation (6) is not very important for the primary planets, but it is important for the satellites.

If there were no bodies in the universe but the sun and one planet, and if these two bodies could be regarded as mere particles, then the preceding investigations would prove that the planet must describe an ellipse about the sun or that each would describe an ellipse about their center of gravity, and that this condition would continue unchanged forever. But, as soon as a second planet appears on the scene, the mathematical precision of the elliptic orbits is destroyed, and the problem of determining the motions of the three bodies becomes infinitely more complex; this is the famous *problem of the three bodies* that has engaged the attention of a long line of eminent mathematicians from the time of Newton to the present day. It would seem that Newton verily lived and made his discoveries in the fulness of time, when providentially he would be followed by a brilliant constellation of mathematicians, who could work out in detail the consequences of Newton's discoveries. The successors of Newton—Clairaut, Euler, D'Alembert, Lagrange, and Laplace—are among the greatest men of science the world has produced.

The investigation of the moon's motion brings us face to face with the problem of the three bodies in one of its forms. If the earth and moon were subject merely to their mutual attraction, the moon's orbit about the earth would be an ellipse, differing but little from a circle. But this convenient state of affairs is disturbed by the attraction of the sun. The determination of the effect of the sun's attraction in disturbing the moon's motion is complicated by the fact that the distances of the earth and of the moon from the sun are continually changing, and do not vary according to any simple law. If Kepler's first law were true, the earth would describe an ellipse about the sun; but really it is the center of gravity of the earth and moon that endeavors to describe an ellipse. The motion of the earth and moon may be illustrated by fastening a large ball and a small one to the ends of a stick, and then suspending the stick from a nail by a long string attached to the stick at the center of gravity of the whole system consisting of the two balls and the stick. Then, if the stick is drawn to one side and swung round, the whole system will revolve as a compound pendulum about the point vertically under the point of suspension. Manifestly, the path of one of the balls is not a simple curve like a circle or an ellipse.

The moon's actual path is an epicycloidal curve intersecting the ellipse described by the center of gravity of the earth and moon twice in every lunar month. The undulation of the moon's orbit is so slight that if the orbit were accurately drawn to a large scale, it would be imperceptible to the eye, and could be detected only by careful measurements. Moreover, the moon's orbit is everywhere concave toward the sun, as may be easily proved in the following way: In the October, 1899, number of "The Mechanic Arts Magazine," we saw that, assuming the earth's orbit to be circular, the centrifugal force per unit of mass due to the earth's orbital motion is $\frac{4\pi^2 r}{T^2}$, and therefore the centripetal force exerted by the sun on a unit of mass at a distance r from the sun is $\frac{4\pi^2 r}{T^2}$; putting for T its value in seconds and for r its value in feet, we get

$$\frac{4\pi^2 r}{T^2} = .0194.$$

Again, the force exerted by the earth on a unit of mass at the moon is

$$\frac{g}{(60)^2} = .0089.$$

Therefore, even when the earth and sun pull the moon in opposite directions, each unit of the moon's mass is more pulled toward the sun than toward the earth; consequently, the moon's orbit is everywhere concave toward the sun.

It is not easy to give the general reader any distinct conception of the difficulty of the problem of the three bodies. We can only explain that the quantities which fix the moon's position are to be determined by means of certain algebraic equations, and that the construction of these equations involves the operation of integration; but the quantities on which this operation of integration is to be performed depend on the moon's position, and so the integration cannot be performed unless we first know the very thing that is to be determined by means of the integration. The solution of the problem, therefore, can be attained only by some

method of successive approximation: first, a quantity is found that is nearly equal to the quantity to be determined; then, this first approximation is used to obtain a second and closer approximation; and so on. The difficulty and complexity of the investigation, even with all the resources of modern analysis, are so great that none but the very greatest mathematicians have been able to obtain satisfactory results. The problem of the three bodies in its general form has hitherto completely baffled the mathematicians; but in the particular form in which it presents itself in the lunar theory it yielded to certain methods of approximation; and these approximations were possible only on account of the orbits being nearly circular and lying nearly in the same plane and some other favoring circumstances. Lagrange used to say, "If nature had not favored us in this way there would have been an end of the geometers in this problem." The theory of the planets and the theory of comets present the problem of the three bodies in different forms, but neither in the planetary nor in the cometary theory can we employ the methods of approximation that were effective in the lunar theory.

The determination of the inequalities produced by the attraction of the sun in the motion of the moon, or of any satellite, is the problem to which Newton devotes the sixty-sixth proposition of his Principia. We have endeavored to show how this problem has taxed the ingenuity of later mathematicians with all the powerful engines of modern analysis; yet, in his sixty-sixth proposition, Newton attacks the problem—basing his investigation on the few simple principles he had already established, and using only the elegant methods of his simple geometry. He not only succeeded in calculating the principal lunar inequalities then known, but he discovered two other inequalities hitherto unknown and unsuspected. For sixty years after the publication of the Principia, no one was able to carry the investigation any further than Newton had gone; and to this day, no one, employing his methods, has been able to add anything of value to what he had done. Clairaut, deeply impressed by the power of Newton's geometrical methods, attempted to perfect the lunar theory by the Newtonian method; but he was finally compelled to abandon geometrical methods and resort to analysis. The Newtonian geometry is a mighty weapon that none but he could wield, and men still gaze on it in amazement, wondering what manner of man he was who could use, lightly and easily, a weapon that the greatest of his successors could scarcely lift.

Newton did not work out all the inequalities of the solar system; mathematicians and astronomers have been working at these problems ever since, and much yet remains to be done; but there is not now a single irregularity or inequality in the solar system that observation has become precise enough to detect that has not been satisfactorily explained and its value accurately calculated on Newtonian principles. Newton was handicapped in his investigation of these problems by the undeveloped state of practical astronomy. The publication of Newton's Principia placed theoretical astronomy far in advance of practical astronomy, and little more could be done by mathematical astronomers till the practical astronomers, by the improvement of astronomical instruments and the accumulation of accurate observations, should be able to supply the data required by the mathematicians.

The general statement of the nature of the inequalities produced by the sun in the motion of a satellite, given by Newton in the sixty-sixth proposition of the first book of the Principia and its twenty-two corollaries, is one of the clearest presentations of this difficult problem that has ever been made. When he came, in the third book, to apply these general principles to the lunar theory, and to compute the amounts of the several inequalities, he required certain data that could be ascertained only in an astronomical observatory. The Royal Observatory of England was built and endowed in 1676, by King Charles II, at the suggestion of Sir Christopher Wren, and the Rev. John Flamsteed was appointed first Astronomer Royal. Flamsteed proved himself a competent and diligent observer, and compiled many useful astronomical records. He invented the exceedingly valuable method of drawing maps by projecting the surface of a sphere on an enveloping cone, so that, when the conical surface is unrolled, we have a flat map. He died at Greenwich in 1719.

To Flamsteed, naturally, Newton applied for the data he required. But Flamsteed, unfortunately, had a very exaggerated idea of the importance of his office; he thought it was a mighty condescension for a practical astronomer, with beautiful new instruments of surpassing accuracy, to supply figures to a mere theorist who sat in his room and foolishly dreamed of discovering something from

the hieroglyphics he wrote on paper. In Baily's "Account of the Rev. John Flamsteed," it is stated that Flamsteed wrote to a correspondent: "I have determined to lay these crotchets of Sir Isaac Newton's wholly aside." Newton received some scanty information from Flamsteed; but frequently applied in vain for records he required, though he pointed out to Flamsteed how much the value of the observations would be enhanced by the theory. "If you publish your observations," Newton writes in 1694, "without such a theory to recommend them, they will only be thrown into the heap of the observations of former astronomers, till somebody shall arise that by perfecting the theory of the moon shall discover your observations to be exacter than the rest; but when that shall be God knows; I fear not in your lifetime, if I should die before it is done. For I find the theory so very intricate, and the theory of gravity so very necessary to it, that I am satisfied it will never be perfected but by somebody who understands the theory of gravity as well or better than I do." The world might be full of magnificently equipped observatories, in which expert and indefatigable observers might work continually at nightly observation and daily reduction, to all eternity, and yet they could never arrive at a true lunar theory; such a theory could only be discovered by a Newton. Moreover, Newton did not need the observations to construct his theory; he boldly *assumed* his theory on the basis of the three laws of motion and Kepler's three laws—it was a *pure speculation*, subsequently verified by agreement with facts; the theory was formed and Flamsteed's observations were wanted to determine what mathematicians call the *constants*.

Baily's "Account of Flamsteed," alluded to above, was published by the British Admiralty for free distribution, and Mr. Baily was instructed to prepare a list of persons to whom the book should be presented. When the Lords of the Admiralty examined Mr. Baily's list, they found in it names of persons who, as their lordships supposed, possessed no scientific or other distinctions that would justify the presentation of the book to them. Their lordships directed their secretary to interview Mr. Baily on the subject; at this interview the secretary said, "Mr. Baily, their lordships are of opinion that you have included in this list names that are not of sufficient eminence."

"Would you kindly mention some of these names?"

"Well," said the Secretary, "here's Gauss; who's Gauss?"

"Gauss, Mr. Secretary, is the oldest and greatest living mathematician."

"O-o-oh! Well, Mr. Baily, we will see about it, and I will write you a letter."

This letter expressed their lordships' approval of the list. The story is worth preserving, for it has an excellent moral: if you are anxious for fame, seek it in any other field rather than in that of pure mathematics. This story is told by Professor De Morgan; who also gives the following letter, which he found among Mr. Baily's papers:

3 ASTRONOMERS' ROW, PARADISE,
February 14, 1836.

DEAR SIR:—I suppose you hardly expected to receive a letter from me dated from this place; but the truth is that a gentleman from our street was appointed guardian angel to the American Treaty, in which there is some astronomical question about boundaries. He has got leave to go back to fetch some instruments which he left behind, and I take this opportunity of making your acquaintance. That America has become a wonderful place since I was down among you; you have no idea how grand the fire at New York looked up here. Poor dear Mr. Flamsteed does not know I am writing a letter to a gentleman on Valentine's day; he is out walking with Sir Isaac Newton (they are pretty good friends now, though they do squabble a little sometimes) and Sir William Herschel to see a new nebula. Sir Isaac says he can't make out how it is managed; and I am sure I cannot help him. I never bothered my head about these things down below, and I don't intend to begin here. I have just received the news of your having written a book about my poor dear man. It's a chance that I heard it at all; for the truth is, the scientific gentlemen all are somehow or other become so wicked, and go so little to church, that very few of them are considered fit company for this place. If it had not been for Doctor Brinkley, who came here, of course, I should not have heard about it. He seems a nice man, but is not yet used to our ways. As to Mr. Halley, he, of course, is not here; which is lucky for him, for Mr. Flamsteed swore the moment he caught him in a place where there are no magistrates, he would make a sacrifice of him to heavenly truth. It was very generous of Mr. F. not appearing against Sir Isaac when he came up, for I am told if he had, Sir Isaac would not have been allowed to come in at all. I should have been sorry for that, for he is a companionable man enough, only holds his head rather higher than he should do. I met him the other day walking with Mr. Whiston, and disputing about the deluge. "Well, Mrs. Flamsteed," says he, "does old poke-the-stars understand gravitation yet?" Now you must know this is rather a sore point with poor dear Mr. Flamsteed. He says Sir Isaac is as crotchety about the moon as ever; and as to what some people say about what has been done since his time, he says he would like to see somebody who knows something about it of himself. For it is very singular that none of the people who have carried on Sir Isaac's notions have been allowed to come here.

I hope you have not forgotten to tell how badly

Sir Isaac used Mr. Flamsteed about that book. I have never quite forgiven him; as for Mr. Flamsteed he says that as long as Sir Isaac does not come for observations he does not care about it, and that he never will trust him with any papers again as long as he lives. I shall never forget what a rage he was in when Sir Isaac called him a puppy. He struck the stairs all the way up with his crutch, and said puppy at every step, and all evening as soon as a star appeared in the telescope he called it puppy. I could not think what was the matter, and when I asked he only called me puppy.

I shall be very glad to see you if you come our way. Pray keep up some appearances, and go to church a little. St. Peter is always uncommonly civil to astronomers, and indeed to all scientific persons, and never bothers them with questions. If they can make out anything of a case, he is sure to let them in. Indeed, he says, it is perfectly out of the question expecting a mathematician to be as religious as an apostle, but that it is as much as his place is worth to let in the greater number of those who come. So try if you cannot manage it, for I am very curious to know if you found all the letters. I remain, dear sir,

Your faithful servant,

MARGARET FLAMSTEED.

So far we have endeavored to indicate the progress of Newton's investigations up to the end of the eleventh section of the Principia; up to this point Newton treated all the bodies as mere particles, and the results are only true in so far as we can neglect the dimensions of the bodies in comparison with the distances between them.

THE GALVANOMETER.

James E. Boyd.

WHAT IT IS USED FOR—THE TANGENT GALVANOMETER—HOW THE STRENGTH AND DIRECTION OF AN ELECTRIC CURRENT IS OBTAINED.

A GALVANOMETER is an instrument for measuring the strength of an electric current. The name galvanometer is now most frequently applied to instruments for measuring small direct currents. Instruments for measuring large direct currents are usually graduated so as to read amperes, and are called ammeters. For alternating currents, we use alternating-current ammeters and dynamometers. All of these are types of galvanometers.

The simplest galvanometer consists of a magnetic needle placed near a coil of wire that carries the electric current. The magnet lies horizontal and is free to turn around a vertical axis through its center. It may be supported on a pivot or it may be suspended by a thread. The magnet is generally placed at the center of the coil of wire, but it may be above the coil or below it.

FIG. 1.

Then there must be some way of measuring the amount of deflection of the needle when the current flows in the coil. This is accomplished by placing a graduated scale underneath the magnet. In Fig. 1 we have such a galvanometer. The needle and its scale form an ordinary compass placed at the center of the coil and the whole rigidly fastened to the base. In the better instruments the base is provided with three leveling screws. The card or scale beneath the instrument may be graduated in degrees or any other convenient way.

Suppose we wish to use the instrument shown in Fig. 1. We place it on a table or shelf and notice whether the needle swings free. If there is no stop to hold it, we probably find that it does. If it does not, we look carefully and find that one end is apparently lower than the other, indicating that the one side of the instrument is too high. We lower that side until the needle is parallel to the scale underneath it. When free to move, the needle sets itself in the magnetic meridian. The instrument must now be turned until the plane of its coil is also in the meridian, the needle lying in one diameter of the coil.

Now, when a current flows in the coil we have lines of force through it, the direction of which depends on the direction of flow of the current around the coil. If the current flows in a clockwise direction, the lines are away from the observer, and the needle is deflected around to some position such as that represented by the dotted line.

We now see the reason for having the coil in the same vertical plane as the needle. In

this position its lines of force are horizontal and at right angles with the needle, so that they exert the greatest force to turn it from its position of rest.

An instrument arranged in this way is called a *tangent galvanometer*, because the strength of the current is proportional to the tangent of the angle of deflection. We know that when two forces act on a body the effect is the same as that due to a single force called the *resultant* of the two forces. The size and direction of this resultant is obtained by the method of the parallelogram of forces. From any given point such as O, Fig. 2, draw line OX to represent one force, and another line OY to represent the other. The direction of these lines are the same as the forces they represent, and their length proportional to the amount of the forces. Complete the parallelogram by drawing XZ parallel to OY and YZ parallel to OX. The diagonal OZ from the point of beginning represents the resultant of the two forces.

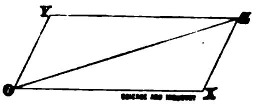


FIG. 2.

Now, in the tangent galvanometer, we have the earth's magnetism pulling north on the north pole of the needle, and that due to the coil pulling east or west, as the case may be.

Suppose the force due to the earth is 20 and that due to the coil is 10. We represent the first by the line ON, Fig. 3, and the second by the line OE, one-half as long as the first. The line OZ gives the direction the needle tends to point, and the angle between NO and ZO is the angle of deflection.

If, now, the current in the coil is made three times as great, the force will be represented by OF, which is three times as long as OE, and the resultant by OZ'. The angle deflection $Z'ON$ is not three times as great as ZON, but its tangent is exactly three times as great.

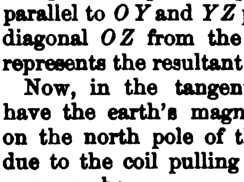


FIG. 3.

The tangent of an angle is defined as the ratio of the side of a right-angled triangle opposite the angle to the side adjacent to the same angle. Here NZ opposite the angle NOZ is one-half of NO, and the tangent of NOZ is $\frac{1}{2}$. In the same way the tangent of NOZ' is NZ' divided by ON, or $\frac{3}{2}$, which is three times that of NOZ.

If we wish to use a tangent galvanometer to find how many times one current is greater than another, we must measure their angles of deflection and determine their tangents either from a tangent table or by constructing the triangles.

A good tangent galvanometer has a comparatively large coil and a very short needle. This is on account of the fact that the force around the coil varies, and it is necessary to have the needle remain in a field of constant strength as it swings about.

In order to have a large open scale with such a needle it is customary to fasten to it

FIG. 4.

at right angles a long light aluminum pointer like that shown in the instrument of Fig. 4. When a galvanometer for greater sensitiveness has a small coil close to the magnet, it is often provided with a pointer. The magnet is partly hidden by the coil, while the pointer at right angles to it comes out so that it may easily be read.

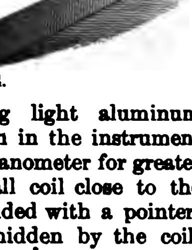


FIG. 5.

The question may be asked: What is the effect of the strength of the magnet poles on the angle of deflection of the needle? The angle is the same whatever the pole strength, provided there is no friction at the pivot. If the pole strength is doubled the pull due to the earth's field is doubled and that due to the coil is also doubled, so that the resultant force has the *same direction* as before,

though it is twice as great. The position at which the needle tends to come to rest is the same whatever its pole strength.

Suppose $O A$, Fig. 5, represents the direction of the resultant force, and the position to which the needle would come if there were no friction. If there is considerable friction, the needle may stand at B or at C or anywhere between them. The greater the friction and the weaker the magnet, the farther will these points be from A, and the more inaccurate the readings. If the needle moves up from N towards A very slowly, it may stop at B. If it comes up quickly, its momentum may carry it beyond A or beyond C. When there is considerable friction it is advisable to take two readings, one with the needle going in one direction and the other with it going in the other direction, at each reading tapping gently on the base of the instrument to shake the needle down, as it were, to its position of rest. The average of these two readings may be taken as the correct one.

Do not tap the glass cover of such a galvanometer, for the friction of the hand on the glass often produces a charge of static electricity on the glass, which attracts the needle or pointer and changes the results.

INDIAN SUMMER.

Geo. S. Hodgins.

Characteristics Marking Its Advent—Supposed Causes of the Season—The Theory That Accounts for All Its Peculiarities.

THE beautiful, warm, balmy, hazy days that often succeed the first sharp frosts of early autumn have been called by the poetic name of Indian summer. The duration of this, the most delightful period of the year, varies indefinitely from year to year. Its advent is as irregular as the early frosts. The only constant factor in the problem of its production seems to be that it invariably follows the first and almost unexpected frost in the early days of the fall. The cause of the heat developed during this period, giving to the air its soft balmy warmth and the delicate haze that hangs in the tranquil atmosphere, has been the subject of much speculation.

It has been held by some that the great forest fires, which are generally more numerous at the end of a hot dry summer, culminate in this short but beautiful season. The smoky air consequent upon the burning of so many myriads of trees and such large quantities of underbrush is thought to account for the bluish haze noticed at this time. The true haze of Indian summer is not smoke at all, however mild and diffused it may appear to be. If this theory of the production of these warm days is correct, we would expect them to have no connection with the first sharp frost of the fall. If due to combustion in any form, the smoky atmospheric haze would not disappear with the advent of the subsequent and more severe frosts of the late fall. If due to forest fires, the smoky air would last until the fires had been actually quenched by the winter snows. We would, upon this hypothesis, have Indian summer only in years prolific in forest fires, and we would also have more pronouncedly warm days, and more of them, too, in the autumn of those years in which the fires had raged most fiercely. The fact, however, is that Indian summer often comes upon us in years when there have been almost no forest fires. The phenomena are immediately preceded, and, indeed, produced, by the first frosts of fall, and are entirely destroyed by the subsequent sharp frosts. The forest-fire theory does not seem to satisfactorily explain all the facts.

It has been argued by others that the freezing of the great bodies of water in northern latitudes is a cause competent to produce what we call Indian summer. The freezing of water certainly does liberate heat in very great quantities. Paradoxical as it may seem, the advent of cold weather does actually call forth, as it were, a protest from Nature in the shape of an immense volume of heat given out as if to fight the power of the Frost King.

Water at ordinary temperatures contains a large amount of heat. The unit of heat, as known to science, is the quantity required to raise one pound of pure water through one degree of temperature, measured on the Fahrenheit thermometer. This amount of heat is called a British thermal unit. It is

not temperature at all, but a definite quantity of heat. In order to clearly understand the quantity of heat contained in water, it is only necessary to consider for a moment a very simple experiment. At the border temperature between melting and freezing, viz., 32° F., a block of ice weighing one pound will require one pound of water, at a temperature of 176° F., to melt it. After the hot water has been poured upon the ice there will be two pounds of water, the whole mass standing at 32° F. A thermometer dipped into the two pounds of water will show the same temperature that the ice registered, that is, 32° F. The heat contained in the hot water has disappeared—it has become latent, as it is termed. Its energy has been employed in breaking up the crystals of the ice. It has done internal work by forcing the molecules of the ice apart, and compelling them to assume the liquid state. This heat of liquefaction, though stored up in the water, is not sensible to the thermometer.

Water will retain this quantity of heat so long as it remains water. It may become warmer, and when it does it may be made to show its heat, but it can never part with this stored up, or latent, heat without at once becoming ice. When a pound of water freezes it gives up 144 British thermal units.

This heat of liquefaction, suddenly liberated from the millions of freezing pounds of water in our great lakes, is poured upon the air in enormous quantities. The freezing of water, however, even in large volume, does not produce the haze in the atmosphere that is one of the concomitants of Indian summer. This theory of the freezing of great bodies of water is, therefore, when weighed in the balance of scientific inquiry, found to be wanting in its endeavor to fully account for the erratic recurrence of this season. It fails to show any cause for one of the physical conditions here so apparent. If Indian summer depended on the freezing of water, then countries having large bodies of fresh water would experience that season of warmth and haze with perfect regularity. Perfect regularity in the appearance of Indian summer we have not; and the freezing of water will in no way account for the hazy atmosphere. If this theory were tenable, the absence of large forest areas would not prevent Indian summer from visiting those lands. It is, however, to the "forest primeval" that we must look for the cause of our hazy and warm season.

A theory brought out by Mr. G. W. Johnson, of Toronto, Canada, accounts for both the warmth of the weather and the soft haze in the atmosphere. He explains that Indian summer is the result of the action of the first frost that nips the thick, fleshy, juicy leaves of our forest trees, and strews them upon the ground before they have dried and withered on the branches.

An idea of the enormous aggregate tonnage of these moist and sappy leaves that fall in the autumn may be gained by quoting here the words of Mr. F. Schuyler Mathews, given in "Popular Science Monthly," for October, 1896. He says: "I have estimated that a certain sugar maple of large proportions, which grows near my cottage, puts forth in one season about four hundred and thirty-two thousand leaves; these leaves combined present a surface to sunlight of about twenty-one thousand six hundred square feet, or an area equal to pretty nearly half an acre."

A rough calculation made by the writer would suggest that this tree may be supposed to have cast upon the ground about one thousand three hundred pounds of leaves, or at least over half a ton. It will easily be seen that the billions of leaves dropped from the myriads of trees in the huge forest areas of this continent must pile up many thousand tons of vegetable matter, deposited on the ground while in full vigor and filled with the juices and sap of life. This mass of matter, severed from the parent trees, begins immediately to decay. Mr. Johnson's theory asserts that a process of fermentation is at once set up that gives off heat in large quantities, and at the same time liberates carbonic acid and watery vapor. The heat given off by the simultaneous decay of so many tons of forest foliage will account for the warmth experienced at this season. The exhalation that rises from the leaves as they decay is sufficient to explain the appearance of the delicate haze that hangs in the air.

From this it will be seen why it is that in some years there is little or no Indian summer. If the leaves remain on the trees until dry and withered, unattacked by an early frost, they fall with no more power to ferment than so many sheets of dry paper. If, on the other hand, the frosts of autumn should be so frequent and so severe as to arrest the process of fermentation before it has well begun, no Indian summer will be noticed. A strong cold wind or sharp frosts will destroy fermentation after it has gone on for some time, and so put an end to the warm hazy days. Mr. Johnson's theory, though not stated verbatim here, accounts

for the phenomena in a satisfactory way.

As forest fires destroy our trees, and as the clearing of farm lands and the rapacious man of the sawmill eat away our forest areas, there will be shorter and less clearly marked periods of Indian summer. Countries in which there are pine, spruce, and other trees that do not produce large fleshy leaves, have no such pleasant season. Some years give us no Indian summer; some produce but a few such days; while others, more propitious, favor a duration of from two to three weeks, or even longer. The name Indian summer is peculiarly appropriate, as the season is the direct product of the forest—the original home of the Indian; and as that race gives way slowly and silently before the advance of the white man, so in time will the forest disappear before our advancing civilization, and the warm, beautiful Indian summer—that exquisite twilight of the seasons—will as silently vanish as the race with which its name is so poetically associated.

THE ARCHED STEEL TRUSS.

SNOW- AND WIND-LOAD DIAGRAMS.

I enclose a sketch, Fig. 1, for a proposed truss, or arch, supporting the roof of a hockey and curling rink, and would ask you to kindly show how the stresses, due to the wind pressure and snow load, may be determined. I would like you to give the graphical methods of solution, and, in considering the snow load, to assume that it occurs upon one slope of the roof only, the other side having been cleared off. I would add that the daily measurements of snowfall at this place during the winter aggregate over 6 feet, weighing, in this condition, 15 pounds per cubic foot.

D. J. McL., Sandow, B. C.

The determination of the stresses, on the truss indicated by our inquirer in Fig. 1, offers little difficulty to solution when the connections at the crown and spring are hinged or pin-connected. If, however, they are not, the problem becomes troublesome and the demonstration too lengthy for the space at our disposal.

It is to be assumed from the shape of the truss at the springing points that it is pin-connected, and as the inquirer marked the apex of the truss "slip connection," it is evident that the intention is to provide a pin at the point *a* as well. The members assembled at the apex *b* are, therefore, so constructed that there will be no rigidity at that point, and the truss will be free to deflect under its load, and free to expand or contract with the changes of temperature. Rollers are also provided at the right-hand spring of the truss to further facilitate the movement of expansion and contraction. Since the truss is free to move in the direction of its plane, the connection *c* must not be rigid, as some movement would take place at this point. Probably the best construction to employ would be to support the roof of the annex, not upon the main-truss members, but upon independent columns erected close to the main trusses.

The problem based on the above assumptions offers, as previously stated, little difficulty to solution, and consists principally in determining the external forces acting upon the truss. These external forces consist of the loads upon the roof and their

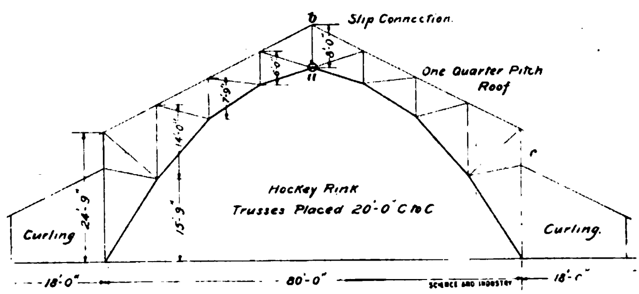


FIG. 1.

accompanying reactions, and they must fulfil the condition of equilibrium, namely, that the algebraic sum of the moments about any point must equal zero.

The snow load upon the roof, owing to the climate in which the building is located, is greater than it is usual to assume, and 60 pounds per square foot will not be excessive. The trusses are placed 20 feet from center to center; therefore, the panel loads, in round numbers, will be as designated in Fig. 2, which is the frame diagram for the

snow load on one side of the roof. In referring to this figure it will be observed that the load $A\,B$ is considerable; for, besides

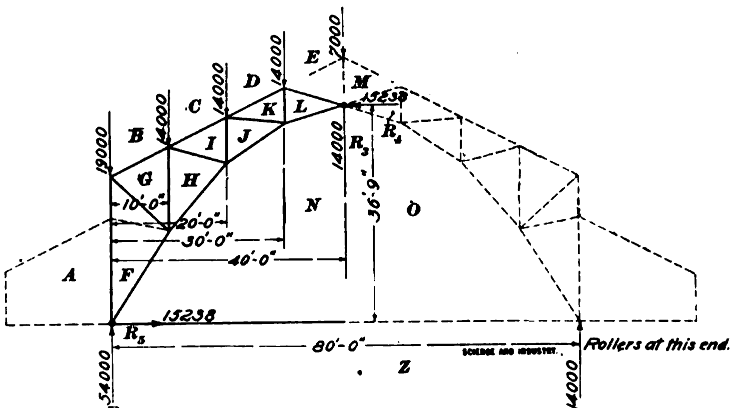


FIG. 2.

the half panel load of the truss, the load upon one-half of the annex roof has been added thereto. This is done to simplify matters, and it is reasonable, because it will be economy to make the member $A\,F$ the same section throughout its entire length.

The reactions R_1 and R_2, in the frame diagram for the snow load, may readily be determined by regarding the entire truss as a simple beam, and calculating by the method of moments. The sum of the moments of the panel loads about the reaction R_1 equals:

$$\begin{aligned} 14{,}000 \times 10 &= 140{,}000 \\ 14{,}000 \times 20 &= 280{,}000 \\ 14{,}000 \times 30 &= 420{,}000 \\ 7{,}000 \times 40 &= \underline{280{,}000} \\ & \quad 1{,}120{,}000 \end{aligned}$$

The reaction R_2 equals the sum of the moments divided by the perpendicular distance between R_1 and R_2, which is the span of the truss. Thus, $1{,}120{,}000 \div 80 = 14{,}000$ pounds, the value of R_2.

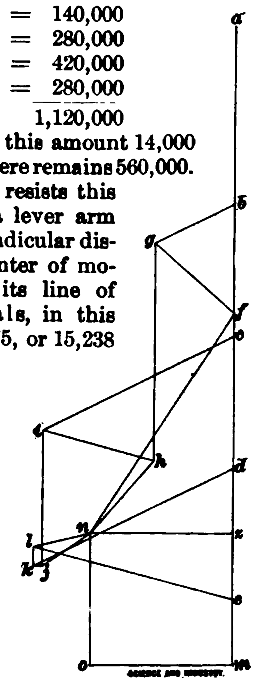
In further treatment of the truss the right-hand section is disregarded, only that portion to the left being considered. Since the sum of the reactions on any structure in equilibrium must equal the sum of the loads, R_1 may be found by deducting R_2, 14,000 pounds, from the sum of the loads, 68,000 pounds, which gives 54,000 pounds. In order that the vertical reactions shall equal the vertical loads, an upward reaction R_3 must be provided at the crown. This reaction equals the vertical shear at this point, and, since there is no load occurring between the right-hand reaction R_2 and the point in question, the amount of R_3 equals R_2, or 14,000 pounds.

The vertical loads, besides creating vertical reactions, owing to the shape of the truss, produce equal and opposite horizontal thrusts at the crown and springing points. To determine the amount of these horizontal reactions, calculate by the method of moments the horizontal force required at the crown to produce equilibrium, considering the pin-connection at the springing points as the center of moments. This calculation will be as follows:

$$\begin{aligned} 14{,}000 \times 10 &= 140{,}000 \\ 14{,}000 \times 20 &= 280{,}000 \\ 14{,}000 \times 30 &= 420{,}000 \\ 7{,}000 \times 40 &= \underline{280{,}000} \\ & \quad 1{,}120{,}000 \end{aligned}$$

Deducting from this amount $14{,}000 \times 40$, or 560,000, there remains 560,000.

The reaction R_4 resists this moment through a lever arm equal to the perpendicular distance from the center of moments at R_1 to its line of action, and equals, in this case, $560{,}000 \div 36.75$, or 15,238 pounds. The thrust at the spring of the truss may be resisted by the foundation acting as an abutment, or by a tension member connecting the springing points of the truss. In this case, as the trusses are on rollers, they must be held against spreading by tie-rods, which are convenient to run under the floor of the rink. The stress in these rods is equal to the thrust at the crown,



Scale $\frac{1}{20}$" = 1000 lb.
Snow Load Diagram

FIG. 3.

or 15,238 pounds, and constitutes the reaction R_5.

All the external forces and reactions having been obtained, the stress diagram for the

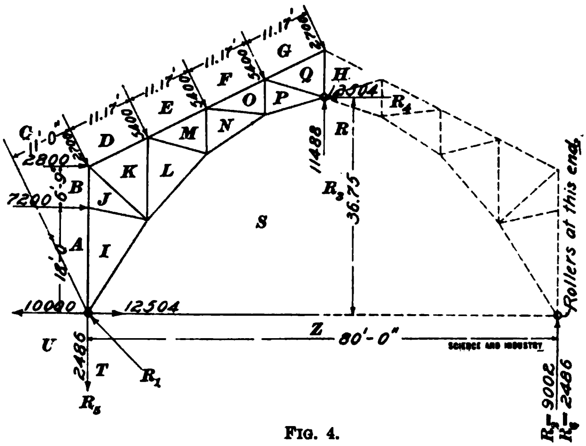


FIG. 4.

snow load, shown in Fig. 3, may be drawn in the usual manner; that is, lay off the load line $a\ b\ c$, etc., and mark upon it the distances $a\ b$, $b\ c$, $c\ d$, etc., which represent to some convenient scale the amount of the loads $A\ B$, $B\ C$, $C\ D$, etc., respectively. Then mark the distances $m\ o$, $o\ n$, $n\ z$, and $z\ a$, equal, by scale, to the reactions $M\ O$, $O\ N$, $N\ Z$, and $Z\ A$, respectively. The polygon of external forces may then be traced from a to b, from b to c, from c to d, from d to e, from e to m, from m to o, from o to n, from n to z, and from z back to a, the starting point.

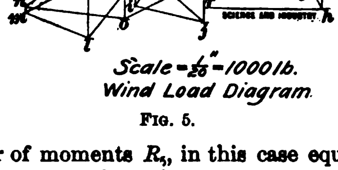
The lines in the stress diagram representing the stresses in the members of the truss may now be delineated by commencing at the lower left-hand joint of the truss. For instance, the point n in the stress diagram is already determined, and by drawing a line from n parallel to $F\ N$ in the frame diagram, the point f will be located at its intersection in the vertical load line. Thus will all the stresses about the joint be determined, and the polygon of forces will be from a to f, from f to n, from n to z, and from z back to a, the starting point. Proceed thus around all the joints, always drawing the lines in the stress diagram parallel to the members they represent, and checking the polygon of forces around the joints to see that they close. The stresses may then be scaled from the stress diagram and tabulated. The kind of stress, that is, whether compressive or tensile, is determined by the direction in which the forces act. Forces that act toward a joint produce compressive stress in the member, and those that act away from a joint create tensile stress.

The determination of the external reactions on the truss, due to the pressure of the wind, is somewhat complicated by the tilting tendency of the horizontal action of the wind on the vertical side of the truss. This tilting or overturning effect produces a lifting at the windward side and a corresponding depression at the leeward side, which produces a vertical downward reaction at one end and a vertical upward reaction at the other.

These reactions are as at R_5 and R_6, Fig. 4, and may be figured by considering the moment of the horizontal wind pressure about the left-hand springing point of the truss. The force $A\ B$ includes the load upon one-half of the exposed vertical surface of the annex as well as the pressure upon the lower half of the member $B\ J$, $C\ B$ being the horizontal pressure upon the upper half of that member. The horizontal force of the wind is taken, in all cases, at 40 pounds per square foot of vertical surface; the calculation, in order to determine the reactions R_5 and R_6, is as follows:

$$
\begin{aligned}
2{,}800 \times 24.75 &= 69{,}300 \\
7{,}200 \times 18 &= \underline{129{,}600} \\
&\ 198{,}900
\end{aligned}
$$

Dividing the sum just obtained by the perpendicular distance between R_6 and the



Scale = $\frac{1}{20}$" = 1000 lb.
Wind Load Diagram.

FIG. 5.

center of moments R_5, in this case equal to the span, or 80 feet, gives 2,486.

The horizontal wind forces also create a horizontal reaction, which, since the right-hand end of the truss is on rollers, will be

assumed as acting at the windward springing point of the truss. This reaction is the force UA, and is equal to the sum of the horizontal wind loads, or 10,000 pounds. The right-hand end of the truss is on rollers, and hence the reaction at this point will be vertical and may be calculated by the method of moments, thus:

$$\begin{aligned} 2{,}700 \times 11 &= 29{,}700 \\ 5{,}400 \times 22.17 &= 119{,}718 \\ 5{,}400 \times 33.34 &= 180{,}036 \\ 5{,}400 \times 44.51 &= 240{,}354 \\ 2{,}700 \times 55.68 &= 150{,}336 \\ & \quad 720{,}144 \end{aligned}$$

Dividing this amount by the span, 80 feet, as previously explained, the upward vertical reaction R_2, at the right-hand end, equals 9,002. The upward vertical reaction R_3, at the crown of the truss, equals the vertical reaction at the right-hand support, which is the sum of R_2 and R_6, or 11,488.

The horizontal thrust at the crown, and the stress in the tie-rods, due to the wind loads, must now be obtained, and may be calculated as follows: The sum of the moments of the oblique forces, around the center of moments at R_5, equals 720,144, and the sum of the moments of the horizontal forces equals 198,900. Adding these, because they act around the center of moments in the same direction, there results 919,044. From this amount it is necessary to deduct the moment of the reaction R_3 about the same center of moments. This moment amounts to 459,520, and, by deducting it from 919,044, there results 459,524. Dividing this by 36.75, the reaction R_4 equals, approximately, 12,504 pounds; this is also the stress in the tie-rods forming the member SZ.

The external forces, due to the wind, are thus determined, and all that remains is to draw the stress diagram, Fig. 5, which is accomplished in the same manner as that for the snow load.

A GOOD HOME-MADE PACKING.

G. E. Desler, Kingston, Jamaica.

PRESUMING that many of your readers, myself included, are greatly benefited by the freely given practical experience of others, that they get through your columns, I venture to give my experience with piston-rod and valve-stem packing, hoping that my experience will benefit others. Every engineer knows what a disagreeable and extravagant thing a leaking stuffingbox is. I do not believe that there is any packing yet invented that will give satisfaction on a rough rod or stem; hence, these must be put in good order before proceeding further. This done, I take round asbestos packing just one size larger than the distance from the top of the rod to the top of the stuffing-box (inside); that is, if this distance measures ⅞ inch, I use 1-inch packing cut to the right length to go around the rod. A sufficient number of pieces should be cut off to make two sets of rings for each stuffing-box. All the rings are wrapped with ordinary white cotton twine, about 6 turns to the inch. Lamp wick may be used, but it must be wrapped much closer than the twine. Now place all the rings in any convenient vessel and cover them with good cylinder oil, to which a liberal allowance of good graphite has been added. Put the vessel on a fire and stir the contents thoroughly, allowing the oil to boil. Now take the vessel off the fire and let it cool slowly. When cool, the packing is ready for use. Put it in the same as any other packing, but do not screw the gland very hard against it until the engine is running, when you may screw it up gradually until there is no leak. Use one set for two weeks; then remove it and boil it in oil and graphite again, using the second set for two weeks. If it becomes ragged at any time, rewrap it with twine.

The life of the packing depends upon the condition of the rod and its speed. In a McIntosh and Seymour tandem compound condensing engine of 150 horsepower, running 12 hours a day at 275 revolutions per minute, two sets of this packing lasted me 12 months. I then passed the old packing to the smaller stuffingboxes, and finally used it for the globe-valve stems. I have also used it in an Armington-Sims non-condensing engine with equally good results. I have been using it for the past 7 years, and I have no desire for anything better. My rods have a beautiful dark-brown gloss, and are as smooth as a looking glass.

This scheme may be old to most of your readers, yet if there is one who, never having tried it, will give it a fair trial, I am sure he will say it is good.

CHAINS AND THEIR USE.

H. Rolfe.

ANTIQUITY OF CHAINS—THEIR GENERAL UTILITY, DUCTILITY, AND STRENGTH—CONDITIONS, FAVORABLE AND OTHERWISE, UNDER WHICH CHAINS USUALLY WORK.

CHAINS have been in use from the earliest times of which we have any record; even in early Bible history they are mentioned as being used both for ornament and for utility. In the days of Joseph the chain was a badge of office, as it is to this day in some countries, and at about the same period the people occasionally indulged in the habit of "binding their kings in chains and their nobles in links of iron." The earliest mention of chains in literature is, we believe, concerning their use for mooring or anchoring ships. They were also used as ornaments for the wrists, ankles, etc., being in that case made of silver, brass, and other metals.

Since ropes, the equivalent of chains, are found everywhere, even if only made of grass or skins, it is fair to assume that the need of chains was felt even in the earliest times, and that as soon as men began to work in metal they fashioned them from it.

The word *chain* is very comprehensive, ranging from the smallest toy chains, in which there may be 50 or 60 links to the inch—the whole weighing but a couple of grains—up to the heaviest chain cables, made out of iron 3 inches or more in diameter, and having a strength of 200 tons and upwards.

We could not very readily conceive of engineering operations being carried on without the aid of chains or ropes. True, in some engineering works, sling chains are now dispensed with in lifting heavy loads — plates, for instance — electricity being employed instead. Any one that has had anything to do with slinging big boiler plates, for lifting, knows they are not the handiest of things to run up and down a shop. But nowadays a large magnet hanging from the crane is lowered to the plate and, the current being turned on, the crane lifts up and carries along overhead a plate weighing some 2,000 or 3,000 pounds with as little apparent effort as a child exerts in lifting a needle with his toy magnet. However, the above is only an exception, and the fact remains that chains are of great importance to engineers, and a wider knowledge of their care and treatment should be prevalent.

Chains are nearly always made of round material, although the links of what are known as *gearing* chains, used for dredgers, etc., are made of flat iron plates. However, we shall here only consider chains made out of round bar iron or steel.

Considering the rough usage to which chains, even under the most favorable conditions, are subjected, they ought to be, and generally are, made of the best iron obtainable; in fact, best quality chains are made of a special brand rolled for the purpose.

Ductility.—Ductility is a most important factor in the manufacture of chains; iron of 54,000 pounds ultimate tensile strength, with an elongation of 25 to 27 per cent. in 8 inches, would be an excellent material for the purpose, though perhaps one would not readily get the elongation test complied with—at least the higher one. Mere tensile strength is not by any means all that is required in chain iron. Some of the most brittle irons possess great strength in tension. Consider hardened and tempered steel, for instance; this is about 2½ to 3 times as strong as the best wrought iron, under *quiet* loads, but will not stand jars or shocks, and is, in fact, one of the very last things of which one would make a chain. Glass also possesses considerable tensile strength, but how long would a glass chain last? These remarks are made merely to bring home the fact that something besides mere strength (under quiescent loads) is required.

Strength and Working Loads of Chains. "The strength of a chain is that of its weakest link," is a very old saying, and is so far true. The presence of one weak spot in any body such as a bar or chain is a great objection, the resulting weakness being greater than is at first apparent; thus, a 1-inch bar 3 feet long turned down to ¾ inch for a width of ⅛ inch, is not as strong as a ¾-inch bar of the same length (see Fig. 1). Also, a chain made of ½-inch links would be stronger, *especially against shocks*, than a ¾-inch chain with one ½-inch link introduced, because in the one case all the *stretch* due to any given shock is taken up by the whole length of the bar or chain, each part of the bar or each

link of the chain taking its share, whereas in the other all the stretch is concentrated on the one small section, or link, and, consequently, rupture is more likely to ensue.

This "strength-of-weakest-link" doctrine applies most emphatically to a chain. In the case of a bridge, if one of the ties or braces were a little weak, it would not be a very serious matter, the result being simply the imposing of a slight extra load on the other members; the same remark would apply if one of the rafters of a roof or of the joists of a floor were weak. But it is a very different matter in the case of a chain; here each link, however strong, can only carry what the link below transmits to it; so, also, any link below the weak one can only support such a weight as a link above it can carry. So it comes about that there can be no half-and-half measures in making the links of a chain; not only must the ninety and nine be sound and of the right strength, but the hundredth one also.

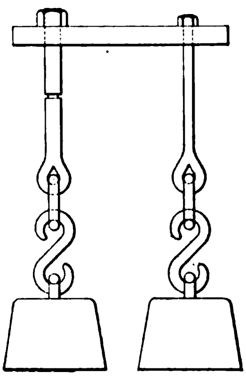


FIG. 1.

The actual breaking-load of a chain in the testing machine can be predicted closely, but it is useless to try to lay down any hard-and-fast rule for the *working load* of a chain, since it depends on so many items, such as (1) the length and breadth of the links; (2) the diameter of the barrel; (3) whether the barrel is grooved or plain; (4) whether or not the chain forms more than one layer on the barrel; (5) the ductility of the iron; (6) the nature of service of the chain; (7) the length of service it has seen, if an old chain.

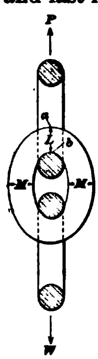


FIG. 2.

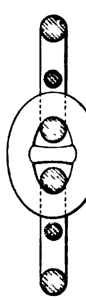


FIG. 3.

Chains are of two principal kinds: the close-link variety, as shown in Fig. 2, and the stud link, shown in Fig. 3. The smaller the link the better, as the chain is obviously more flexible, and the bending stresses are less, as shown further on; the over-all length and breadth may be, respectively, about 4¾ and 3½ times the diameter of the iron M, Fig. 2.

Now, if the link were a very thin and perfectly flexible rope, the tension in M and L would be the same, namely, $\frac{W}{2}$; if W were 4 tons, the stress in any part of the link would be 2 tons, the pull transmitted to the upper link being of course 4 tons; so that, if A were the cross-sectional area of the bar from which the link was made, we might take $2A$ as the available working area. But it is different with an iron link such as shown in Fig. 2—we do not get a fair tensile pull in L. The stress is not uniformly distributed over the section, because bending takes place all around the link, being most severe at a. The link tends to straighten itself out and make the parts M, M come together, and, on account of this bending, combined with the pull of the load, the fibers at a are more strained than those at b. At b, in fact, the metal is in compression, due to the bending action; there is also severe local pressure at the point of contact, due to the pull of one link on the other. In addition to these elements of weakness, there is also the weld at the end to be taken into account; however carefully this welding may be done, the joint will always be weaker than the original bar. Unfortunately, it is more convenient to put this weld at the end L (just where it ought not to be); in ordinary crane chains it is much easier to make the weld at this point, as the link can then be closed up on the point of the anvil and dollied much more readily than if the weld were at the side. However, in larger work, such as in the coupling links shown in Fig. 4 (used in Europe on both freight and passenger cars, and also between tender and car), the weld is generally made at the side, as shown dotted in link a. Sometimes, however, it is made at the end, and the opportunity is then taken to make the section larger, as in link b; for example, the link may be of 1-inch iron and each end made 1⅛ or $1\frac{3}{16}$ inches, the end that is not cut being thickened by welding a piece on.

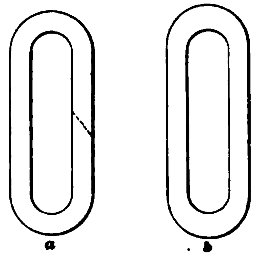


FIG. 4.

It may be imagined that these coupling links, when used on freight cars, undergo very severe treatment. Suppose a train of 50 cars is being started and that there are several inches of slack between the cars;

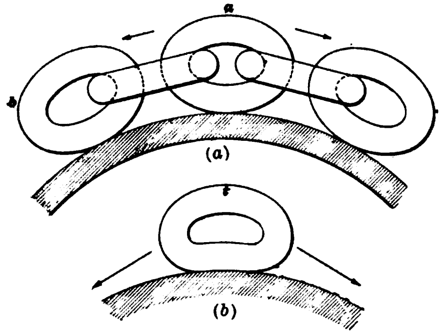


FIG. 5.

evidently, by the time the last car starts the engine will be going at a pretty fast pace and so put a great strain on the rear coupling; also, when making a "flying shunt," if the brakes are put on too abruptly, a coupling (especially that between tender and cars) is liable to be snapped. The wear also comes on the ends, and reduces the section there.

The shorter a link is made the better, for, as there are then more of them in a given length of the chain, the latter becomes more flexible and runs around the pulley or drum more easily, and the bending stresses in the links are not so severe. Close links are generally oval in form; an over-all length of 4¾ d and a width of 3½ d (d = diameter of link iron) constitute good proportions. We will now consider in detail the before-mentioned items that affect the working strength of a chain.

(1), (2), (3).—As regards the bending stress: (*a*), Fig. 5, shows parts of a chain in position on a crane drum, or barrel, that is not grooved. Looking at link *a* it will be seen that the tendency is to distort it, as in view (*b*), putting the top of the link *t* into severe tension; the longer the link the more it will have to bend. When the barrel is grooved, the groove is made of such a depth that the vertical links clear the bottom, and allow the horizontal links to bear on the barrel, as in (*a*), Fig. 6. Here conditions are reversed, *b* being more severely strained than *a*. In this case, also, it will be seen to be an advantage for the link not to be unnecessarily long, for the tendency is to bend the link, as in view (*b*).

Good results follow if the diameter of drum is not *less* than 20 times that of the link iron; for instance, not less than a 15-inch drum should be used for ¾-inch chain, and a 10-inch drum for a ½-inch chain. As these close links are 4⅝ to 4¾ times the diameter of the link iron, the drum diameter should be not less than about 4¼ times the over-all length of the link.

(4), (5), (6), (7).—In large traveling cranes it is arranged that the chain shall form only one layer on the crane barrel, and not overlap as in the ordinary crab or winch. This constitutes an obvious advantage, in that the chain is not then liable to override. This overriding and consequent slipping is the worst thing that can happen to a chain; it often occurs in cranes with the smaller size of chains; the chain partly mounts the coil beneath it and then slips off, the load falling through a certain distance and being then brought up with a sudden jerk. It is *here* that the ductility of the chain proves of value, for the falling load has acquired a certain momentum, and to arrest it a certain amount of work must be done. Work, be it remembered, is measured by the product of the force exerted multiplied by the distance through which it acts; the force is inversely proportional to the distance. Now, the force doing the work is the tensile resistance of the iron, and the distance is the amount of elongation, or stretch; consequently, the more the chain "gives" under

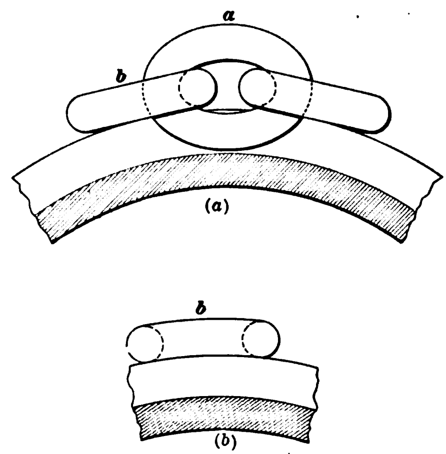


FIG. 6.

the shock, the less is the mean stress in its links. The same bad effects may be induced by lifting a load very suddenly; if a lot of slack had run out and the crane were started rapidly, the load would, of course, come on the chain very suddenly. Or, again, a load may be lowered very quickly and then a powerful band brake be suddenly

applied, the load being brought up with a jerk. A chain that is old has probably already sustained such severe shocks as to be stretched beyond its elastic limit—that is, it has reached its permanent set; but iron in its normal condition is still capable of considerable stretch even after passing the elastic limit, as seen, for example, in the testing machine. An old chain, however, has had its texture changed more or less by these repeated shocks; the iron has become partly crystallized, and so is really unfitted to bear a shock; the new chain has thus a double advantage. The old chain, however, may be restored practically to its original condition by annealing.

AN AWKWARD CONNECTION.

I enclose a sketch, Fig. 1, showing a complicated beam-and-column connection that I had to design. It was not the beam d nor the pair of beams f that gave me trouble, but the system

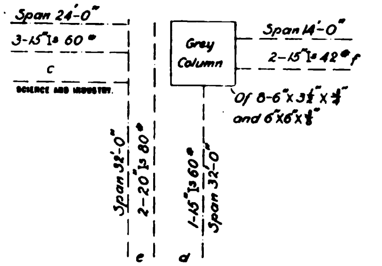


FIG. 1.

e and c. I would like to know how to figure the number of rivets in such a connection, and how it may best be designed; also, whether the eccentricity of loading upon the column should be considered. *W. H. Thorn, Chicago, Ill.*

You do not give the load upon the system of beams *e* and *c*, but we take it for granted that they are fully loaded, and sustain a unit fiber stress of 15,000 pounds. It is reasonable to assume that one-half the entire load on the three 15-in. I's—60 lb. and on the outside 20-in. I—80 lb. bears upon the bracket at *g*, Fig. 2, and that the load upon the inside 20-in. I—80 lb. bears at the point *h*. These reactions act parallel with the center line of the column, tending to turn the bracket about the point *i*, and thus tear it away from the column at the point *k*. The pull at the point *k* produced by these reactions, which must be resisted by a sufficient number of rivets, is equal to the moments of the loads *g* and *h* about the point *i* divided by the perpendicular distance from the point *i* to the line of resistance of rivets designed to resist this pull. In this case, it is equal to

$$\begin{aligned} 74{,}000 \text{ lb.} \times 12 \text{ in.} &= 888{,}000 \text{ in.-lb.} \\ 21{,}000 \text{ lb.} \times 4 \text{ in.} &= 84{,}000 \text{ in.-lb.} \\ & 972{,}000 \text{ in.-lb.} \\ 972{,}000 \div 20 \text{ in.} &= 48{,}600 \text{ lb.} \end{aligned}$$

If $\frac{7}{8}$-inch rivets are used with a unit shear of 9,000 pounds, and a unit bearing value of 18,000 pounds, the value for each rivet will be 5,400; and the number required to resist the leverage on the bracket will equal 48,600 ÷ 5,400, or 9; say 5 through each gusset plate. Of these five rivets, which should be

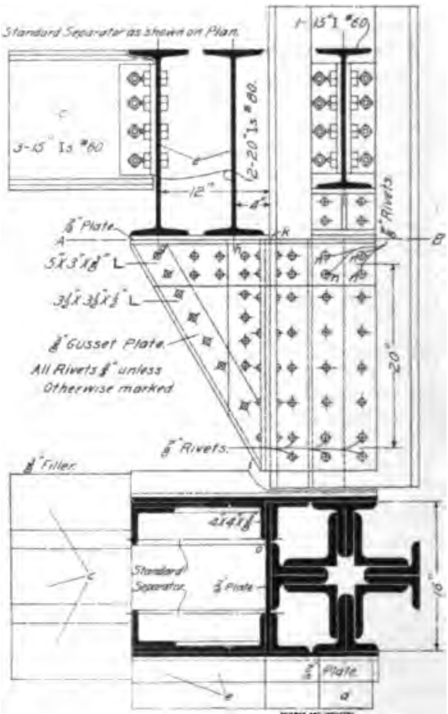


FIG. 2.

placed as nearly as possible in a direct line with the pull, four can be placed at *n*, *n*, as shown. The remaining rivet can be considered as adequately taken care of by the resistance to bending offered by the transverse reenforcing plate at *o*, in the section plan, Fig. 2. Enough rivets besides these

must be provided, to resist the direct shear. Fig. 2 furnishes in detail the other features of this connection, which we have endeavored to design according to the principles of good practice. On account of the loads being at some distance from the center of the column on the side on which the bracket is located, it might be well to consider the bending upon the column due to these loads. The bending upon the column is equal to the eccentric load multiplied by the distance it is located from the center of the column. Having obtained the assumed section of column required to resist direct compression, the rolled sections can be increased in weight enough to provide for the bending.

BOOK NOTICES.

STUDIES FOR LETTERS. By Frances B. Callaway. Published by Williams & Rogers, Rochester, N. Y. Cloth, $6\frac{3}{4}'' \times 4\frac{3}{4}''$, 147 pages. Price, 50 cents.

Most people imagine that to write a letter is a very simple matter. If, however, any one so thinking were fortunate enough to be permitted to read the charming little volume written by Frances Bennett Callaway, "Studies for Letters," he would be likely to think differently. There is no doubt that a faultless letter is a work of consummate art and often of high genius, and that to read all there is in a letter—the lines of it and all that is between them—is frequently more difficult than to decipher a cuneiform inscription.

Some one says that when A engages B in conversation it is marvelous if some disagreement does not arise among the six of them. "The *six* of them? You mean the *two* of them?" "No, I don't; for there is the A that A conceives, the A that B thinks of, and the real A, known only to his maker, and very different from the A of either B or A. There are three A's, you see, and, of course, three B's." The same sextuple duality figures in every letter worthy of the name.

Miss Callaway tells us very charmingly and very forcibly that when we write a letter we leave on the hitherto empty page a very legible account of our personality; our weakness and strength, the whole story of heart and brain and temperament and heredity. She assures us that fortunes and kingdoms and hearts have often been won or lost by this terrible dynamic quality of letters; and she warns us that the same thing will frequently happen hereafter. The most alarming fact in the situation is that we are compelled to agree with her. Was Talleyrand thinking of this deep significance of letters when he said, "Never destroy a letter and—never write one"? Did he believe that a letter has not only a body but a soul also that we have the power to rob of immortality?

If students could be made fully aware of the potentialities lurking between the lines in letters, what an uncountable host there would be in the "Class for the Mastery of the Difficult but Indispensable Art of Letter Writing." And what shoals and shoals of letters would come to Miss Callaway with a "Macedonian cry" for her helpful little book.

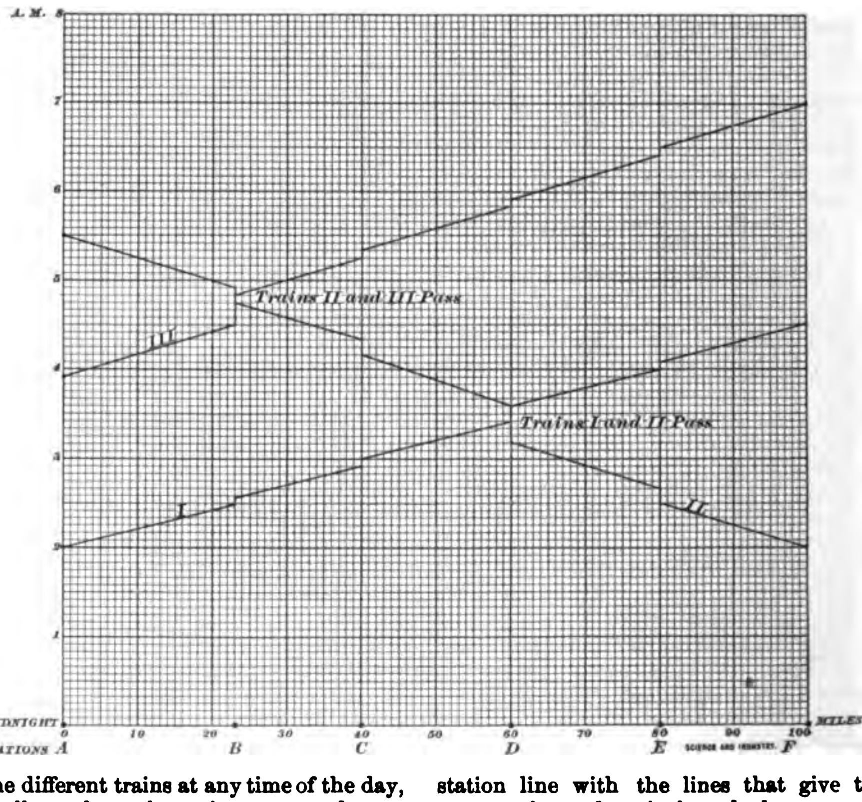
PRACTICAL ELECTRICITY. Published by the Cleveland Armature Works, Cleveland, Ohio. 286 pages, 83 illustrations.

This work is intended to give clear and concise information relating to the several branches of electrical work, and for a book of its size contains a large amount of data. The work contains nineteen chapters in all, of which thirteen relate to dynamos and motors. The first three chapters relate to electric wiring, batteries, magnetism, etc. The last three chapters relate to incandescent and arc lamps, measuring instruments, and alternating currents. The part relating to the design of dynamos is clearly written and contains complete instructions for making calculations regarding the magnetic circuits and windings of dynamos. At the end of each chapter a number of questions are given to bring out the principal points, and the answers to these questions are given in the back of the book. The book is of convenient size for the pocket, is flexibly bound in leather, and, in addition to the matter enumerated above, contains several reference tables. The work was compiled with the assistance of Mr. J. C. Lincoln, a well-known electrical engineer, and we can recommend it to any in need of a book of this kind.

MAKING THE TIME TABLE FOR A SINGLE-TRACK RAILROAD.

In getting out the time table for a single-track railroad, how does the compiler arrange matters so that no two trains shall arrive simultaneously at the same place? H. S. B., Conemaugh, Pa.

In getting out a time table for a single-track railroad, a large "train board" is usually employed, on which is plotted the diagram of every regular train that moves over the division. These diagrams are intended to show at a glance the positions of the different trains at any time of the day, as well as where the trains meet and pass. In the accompanying figure three train diagrams are shown as they would appear on the train board, and they will be employed in explaining the train board and its uses. The board is divided into a number of equal divisions similar to those in the figure. Each horizontal division represents, say, 1 mile, in which case there would be as many divisions horizontally as there were miles of railroad. The vertical divisions represent time, each division representing, say, 5 minutes, and there are a sufficient number of vertical divisions (288 five-minute divisions) to represent the 24 hours of the day. The train diagram of each train is plotted in its order, beginning with the first train after midnight, or train No. *I* in the figure. To plot the diagrams, pins are stuck in the board at the intersections of the station line with the lines that give the proper time of arrival and departure of trains, and a string is fixed on the pins so as to form a curve similar to the curves drawn in the figure. If a new train is to be put on, its curve, when plotted on the board, must intersect other curves (if at all) on some station line, the new curve intersecting the station line below or above the intersection of the other curve, depending on which train has the right of way.



CHIPS & SPALLS.

An Exchange for Members of the Crafts.

Readers are solicited *to send us any inquiries and statements of facts coming under their observation, which they desire to have discussed by their fellow workmen. Any rough pencil sketches, helpful to an explanation, will be touched up, if necessary, and presented in good form.*

Acceptable answers and descriptions of work, other than direct inquiries, will be paid for, when published, at our regular rates.

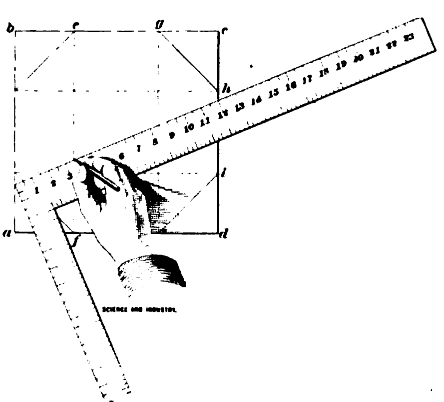
Communications intended for this department should be clearly addressed "C. and S." Editors of SCIENCE AND INDUSTRY, *Scranton, Pa.*

Write on one side of the paper only. Make sketches on separate sheets of paper. The name of the writer will appear in the magazine, unless otherwise requested.

USING THE STEEL SQUARE.

W. J. Vialon, Lake Charles, La.

I NOTICED in a recent issue of "The Building Trades Magazine" an article entitled "The Steel Square." I have a different way



of reading the lumber scale from that given therein that I think is somewhat better. Let me illustrate by an example: Required, the number of feet B. M. in a piece of wood 7 in. × 1 in. × 13 ft. In solving this example with the steel square I use the figures under the 12-inch mark as the width, and the inch marks upon the square as the length of the lumber in feet; for instance, in this case, as there is no 7-mark in the column, I take 14 for the width, and, following this line to the column under the 13-inch mark upon the square, I find the number 15$\frac{2}{12}$; since I took the width as twice the actual width of the board, the number 15$\frac{2}{12}$ must be divided by 2, which gives 7$\frac{7}{12}$, the number of board feet in the piece of wood.

I would also suggest that the octagon scale is of very little use to a builder, as a man can find the gauge lines much easier by the method that I will explain in conjunction with the accompanying figure. Let *a b c d* represent the end section of a piece of squared timber from which it is desired to cut an octagonal stick. Lay the steel square in such a way that any 24 divisions upon it will be contained between two parallel sides. Mark off from either side 7 divisions, and scribe the line *e f*. With the gauge set for the distance *b e*, scribe other lines parallel with the four sides of the square, as shown dotted. Then the points *e, g, h, i*, etc. will be obtained, and the octagon may be drawn as designated. While not exact, this method is sufficiently accurate for all practical building purposes.

MY HOME-MADE PRINTING FRAME.

J. H. McKinly, Clintonville, Pa.

DESIRING a frame for blueprinting, and not having the means to obtain it ready-made, I proceeded to construct one. I procured a clear pane of glass 30 in. × 36 in., and having some cucumber lumber 2$\frac{1}{4}$ inches thick, I sawed out strips 3 inches wide, and worked them with a sash plane, rabbeting the back about $\frac{5}{16}$ inch deep. I then cut these the required length to allow the glass to fit neatly, mitering the corners and securing them with screws, and also reenforcing them with corner irons, such as are used on carriage bodies. I fastened the glass in this frame with glazier's points, and for backing used two thicknesses of table matting, which I held in place with a back board of $\frac{3}{4}$-inch lumber in two pieces, each 18 in. × 30 in. Across the center of each I placed a light batten and screwed to it a strip of springy wood about 1$\frac{1}{4}$ inches wide and 32 inches long, which fastens under catches screwed to the back of the frame. I am thus the proud possessor of a good blueprint frame, 30 in. × 36 in., at a cost of $1.15 for glass, 60 cents for matting, 25 cents for lumber, and probably 10 cents for corner irons, screws, etc., making in all about $2.10, and a wet-day's work.

AN ATTRACTIVE DOOR PANEL.

E. H. C., New Haven, Conn.

THERE ARE lots of good old kinks in wood working that are apt to be lost altogether before long, if we wood workers do not manage to use them once in a while. Last week I found under my bench an old scrap of a detail drawing of a door panel that had been there a dozen years or more. It illustrates one of these kinks, and I think it interesting enough to send you my sketches from it for the Chips and Spalls columns of your magazine. In Fig. 1 is shown the elevation of a door with "drapery-fold" panels, which, as anybody can see, are very effective. Fig. 2 shows how easily they can be made. The panel stuff is first worked to the section indicated with round and hollow planes. The top and bottom of the panel are next beveled off, and the undercutting of these ends can then be done by almost any one who keeps his tools sharp and his wits about him. Try it.

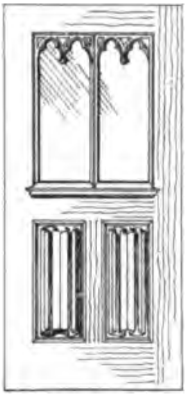


FIG. 1.

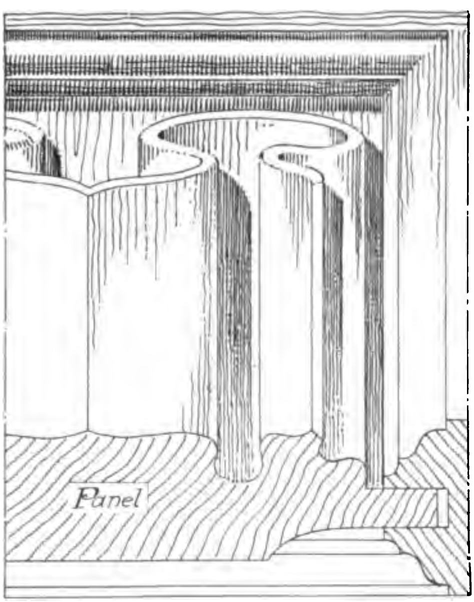


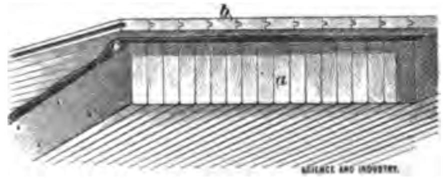
FIG. 2.

GOOD FLOOR CONSTRUCTION.

A. M. C., Chicago, Ill.

IN GOING around among the building operations in this city, I came across a system of slow-burning floor construction that I thought would be of interest to my fellow subscribers, and consequently send the accompanying sketch and description, to which I affix a few of my own ideas, let them be worth what they may.

The floor principals are transverse girders, placed about 14 feet from center to center, no other beams being used. The $2'' \times 8''$ yellow-pine joists *a*, which are spiked together, form a solid wood slab 8 inches thick over the entire floor area; the $1\frac{1}{8}$-inch finished floor *b* being run either diagonally or athwart on top of the joists, with a layer of deadening felt *c* interposed. Such a floor makes capital construction where great stiffness and solidity are required, as in machine shops or factories, where it is necessary to locate heavy machinery at various points on the floor surface, without reference to the beams or girders. By chamfering the under edge of the $2'' \times 8''$ joists, a neat ceiling finish is attained, which, when painted or otherwise finished, gives a shade and shadow effect that is certainly superior in appearance to the usual plank flooring.



In my opinion this construction could be made especially stiff by ordering the joists long enough to span two bays, thus breaking joints on every alternate row of joists at each girder. The joists will then be continuous beams sustained by three supports, and they will in consequence be somewhat stronger than if they spanned only one bay. I think it would also be advantageous to lay the top flooring diagonally, as then it will also span the girders and add resistance to bending. Of course, this style of floor construction will cost considerable more for material; but I think that if some of my contemporaries could devote a little time to figuring its strength compared with the usual construction, they would find that the increased expense would not be great in proportion to the advantage gained.

THE JOINTS IN A THREE-CENTERED ARCH.

John Keenan, Fall River, Mass.

I HAVE noticed in some of your magazines the question, "How shall I set my lines to get the direction of the joints in a three-centered arch built with brick?" so I offer the following solution:

Let *a*, *b*, and *c*, Fig. 1, be the points from which the curve is struck. Drive a pin or nail at each point, and fasten a piece of cord to *a*. Hold the cord in the position *a d*, so that it just touches the point *b*, and mark the point *f* on the wooden center. In like manner locate the point *g*.

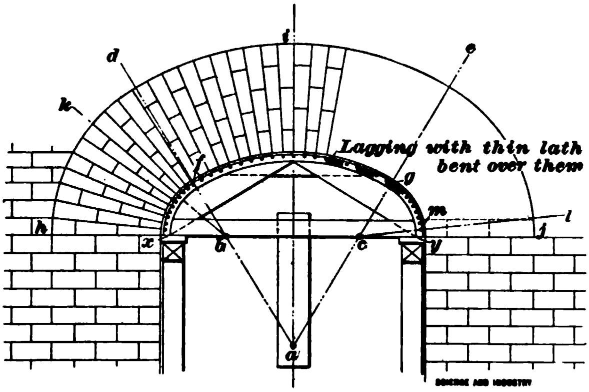


FIG. 1.

Observing *h i j*, the outer curve, or extrados, of the arch, it will be noticed that the spaces for each course of brick on this curve are equal; but not so with the inner curve, or intrados, of the arch, for, as seen in Fig. 1, the spaces between *f* and *x* and *g* and *y* are smaller than those between *f* and *g*.

As the arch ring in this case is 20 inches wide on the face, place two and one-half brick at the springing line, as shown at *m j*; hold the cord in the position *a c l*, allowing a little more space than the width of a brick at the outer curve of the arch for a mortar joint, and mark the point *m* on the wooden center. The distance *m y* is the space for each course of brick between *g* and *y* and *f* and *x*, and the arch is spaced with that distance on both sides up to the points *f* and *g*. It is usual to lay a few courses of brick on one side of the arch beyond, say, the point *f*, to determine the width of the spaces between *f* and *g*, which are found in the same manner as previously described. The spaces should then be marked on the wooden center, varying them, if necessary, so that there will be a full space for the last course.

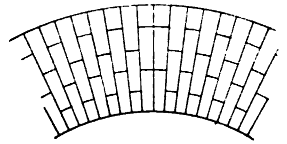


FIG. 2.

So far the bricks are laid on one side of the arch only, and one or two courses beyond *f*. The divisions or joints of the arch being spaced, count the number of spaces in the whole arch. If there is an even number of spaces, the arch must start opposite at the spring; that is, a header on one side and a stretcher on the other, or the arch will come up at the key, as shown in Fig. 2, which is known to the trade as coming up a "she." To avoid such a contingency, bricklayers should always remember this rule: for an even number of courses start odd, and for an odd number of courses start even. It will be noticed, in Fig. 1, that the opposite bricks on the jambs are unlike, or "odd," as it is said to be, and this fact predetermines according to the rule that the arch must contain an even number of courses.

It may also be stated here that a three-centered arch may be laid out that will correspond so closely to a semielliptical, that, in brickwork, it may be substituted for the last mentioned. The carpenter that makes the center should locate the points for the bricklayer to work from.

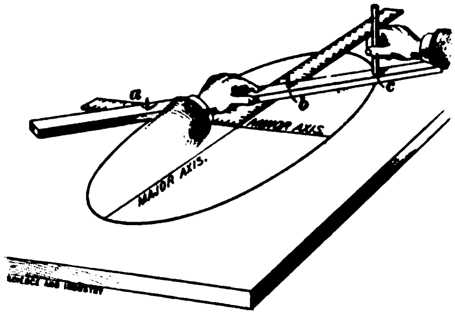
A SHOP METHOD OF DRAWING AN ELLIPSE.

C. S. I., Camden, N. J.

IN OUR shop we have considerable colonial work on hand, and among other details a number of elliptical windows to construct. I was watching the foreman as he laid out the work, and was struck with the novel method he used to describe the ellipses. He explained to me that he adopted this method in preference to using a cord fastened at the foci, because the cord was liable to stretch and thus distort the figure, also that it was bothersome to rig up the cord every time.

The method as he applied it is clearly shown in the accompanying figure, and may be described as follows: Draw on the board the major and minor axes of the ellipse and place at their intersection the steel square,

which is secured in the position shown. Then take a piece of molding strip and drive



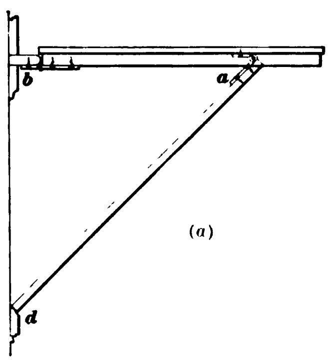
part way through it, the two wire nails *a* and *b*; also bore a hole at *c*, in which a carpenter's pencil will fit tight. The distance from *c* to *b* is equal to one-half the minor axis, and the distance from *c* to *a* is equal to one-half the major axis. By placing the heads of the wire nails *a* and *b* against the two edges of the steel square, keeping them always against it, and moving the pencil around, one quarter of the ellipse may be drawn. By changing the steel square about, the complete ellipse may be described. The wood strip, or molding, may be kept handy, and, by changing the position of the wire nails, may be used any time.

I thought this quite a practical method that might be of interest to my fellow workmen, though no doubt they know of several methods equally as good. If they do, I for one would be pleased to hear from them through these columns.

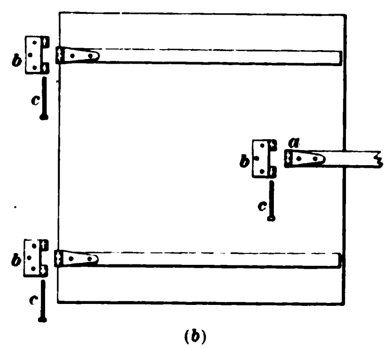
ANOTHER CHEAP DRAFTING TABLE.

Edwin J. Newton, Chicago, Ill.

TO MAKE a cheap drafting table, get three T hinges, like those shown in the sketch, with a removable pin. Fasten one to each of the strips underneath the drawing board, as shown, and fasten the parts *b* of the hinges to the under side of a window sill, as shown in the side elevation (*a*). Then



(*a*)



(*b*)

attach part *b* of the remaining hinge [see view (*b*)] to the board, about one-third the width of the board from the right-hand edge, as shown; attach part *a* of this hinge to a strong stick or broom handle. Attach the stick to the board and the board to the window sill by inserting the pins *c*. The board may be held in a horizontal position by resting the lower end of the stick on the mopboard, as at *d*, or may be adjusted lower by resting the lower end of the stick on the floor at various distances from the wall. If there is no mopboard in the room, a sort of a ratchet block may be fastened to the wall near the floor, without greatly marring the appearance of the room.

If the supporting strut were made in two pieces that would fold or slide the one into the other, similar to the tripod of a camera, and a thumbscrew provided to clamp them in place, the bother of removing the hinge pins would be eliminated. The strut could be folded under the board and the board dropped down by the window, where it would be always ready for instant use. The ends of the hinges *b* are scarcely visible when the board is removed from the window. If so much light directly in the eyes is an objection, this may be remedied by wearing an eye shade.

ANSWERS TO INQUIRIES

NOTE.—*Address all letters containing questions to be answered in this department to* SCIENCE AND INDUSTRY, *Scranton, Pa.*

1. *Put this address both on the envelope and at the head of the letter.*

2. *Only questions of general interest to our readers will be answered.*

3. *No questions will be answered by mail.*

4. *Drawings or sketches accompanying questions should be made on a separate sheet of paper, and should be drawn as clearly as possible.*

5. *The names and addresses of the writers must accompany the letters, or no attention will be paid to them. Unless otherwise requested, we will publish only the initials and address of the writer.*

6. *Reference to inquiries previously answered should give date of issue and number of question.*

7. *Any book not out of print and for sale by regular dealers may be ordered through the magazine.*

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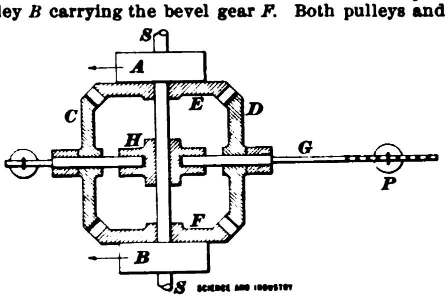
(375) What will be the required horsepower of an engine to drive a centrifugal pump that is to raise water 20 feet and discharge it at the rate of 500 gallons per minute? The pump is to be used at an altitude of 3,500 feet. F. M., Toronto, Can.

ANS.—From 5 to 8 horsepower, depending on the conditions. With a pump correctly designed for the work, 5 horsepower should be sufficient; under less favorable conditions, more power would be required.

***

(376) (*a*) Does the differential transmission dynamometer absorb any of the power transmitted through it other than the friction of its moving parts? (*b*) Explain the operation of this dynamometer. (*c*) Where can I obtain a catalogue of the latest types? P. H. P., Bound Brook, N. J.

ANS.—(*a*) No. (*b*) The essential part of this dynamometer consists of four bevel gears, as shown in the accompanying sketch. Power is applied to pulley *A* carrying the bevel gear *E*. The machine whose work or resistance is to be measured is belted to the pulley *B* carrying the bevel gear *F*. Both pulleys and

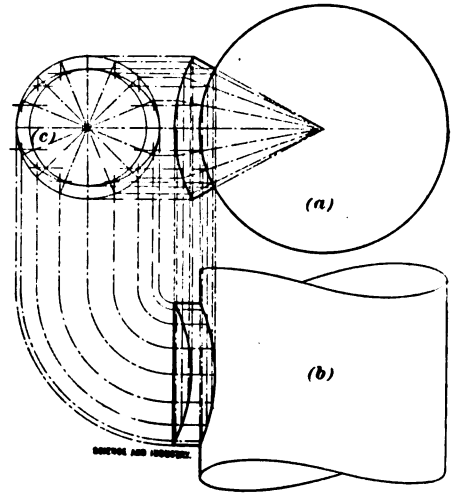


attached gears are loose on the shaft *S*. Connection between gears *E* and *F* is made by gears *C* and *D* running loosely on the lever *G*, which latter is free to swing around shaft *S*. Evidently *B* runs in a direction opposite to that of *A*. The pressures between gears *E*, *D* and *F*, *D* are directed upward, while those between *E*, *C* and *F*, *C* are directed downward, both tending to swing the lever *G* around the shaft *S*; this motion is prevented, however, by a weight *P* balancing the pressures previously mentioned. The magnitude of this weight *P*, multiplied by the distance it would travel, if free to move, measures the power transmitted. It is a peculiarity of this gear-train that if *G* were free to move, it would turn around *S* half as fast as *A*. The magnitude of the force *P* (the weight of the weight) multiplied by the distance it would pass through per minute, if free to move, gives the work done per minute. (*c*) Florence Machine Co., Florence, Mass.

***

(377) I wish to make a working drawing of a bossed flange and want to indicate that the edge of the flange is at all parts perpendicular to the surface of the 20-inch pipe that it is to fit. How may this be indicated on a working drawing? V. G. M., Cleveland, Ohio.

ANS.—In order to indicate this feature of the work, it is necessary to draw the lines of intersection in



several views as they would actually appear in the finished article. This is accomplished in the accompanying drawing, where it is assumed that an end view of the flange is a circle, as shown at (*c*). The projection is then made in the usual manner and it is found that the lines of intersection in the view at (*b*) are not parallel curves, as in the sketch submitted by the correspondent. The difference is so slight, however, that it would probably escape the attention of the patternmaker if his attention were not directed to it by a note on the drawing. If three views are presented, as in the illustration, the chances for error in this particular will be lessened, since but one construction is possible.

***

(378) Kindly answer the following questions concerning the universal joint shown in the enclosed sketch: (*a*) When *A* is raised or moved from side to side, *D* slides out of *C*. Is this covered by any patent? If you do not know, how can I find out? (*b*) How far above the horizontal can *A* be raised and still work satisfactorily? (*c*) About what power will this coupling safely transmit when made of tool steel, and, also, what power when made of machine steel?

(*d*) If this style of coupling is covered by patent, how can I obtain the right to use same in a machine I think of building? (*e*) If patented, how can I find out the patentee's name and address?

C. O. S., Schenectady, N. Y.

ANS.—(*a*) The feature of *D* sliding in *C*, permitting change of distance between centers of couplings, may be patented in combination with the other parts of this particular make-up of an old well-known

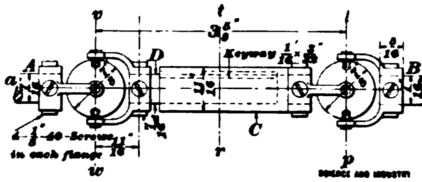


FIG. 1.

mechanism. We think, however, that a patent of this kind could not be sustained. You may find out if a patent exists, as well as the name of the patentee, by having a patent attorney make a search for you in the patent office at Washington. The usual fee is $5.00. (*b*) Working satisfactorily means for a mechanism first of all that it fulfils the purpose for which it is intended. Now the purpose of using two universal joints connected by an intermediate shaft is to have uniform motion of the driving shaft *A* result in uniform motion also of the driven shaft *B*, otherwise one coupling would suffice. To secure the uniform motion of *B*, however, two more conditions must be fulfilled, namely: (1) The angle between shafts *B* and *C* must be equal to that between *A* and *C*. Thus, if the position of *A* and *C* is fixed, the center line of *B* may have any position on a cone whose apex angle is double that between *A* and *C*, as indicated in Fig. 2, at B, B_1, B_2, etc. (2) The two couplings must be symmetrically arranged; that is to say, the member $a\,b$ of the cross of the one must fall into the plane determined by *A* and *C* at the same time as the member $a'\,b'$ of the other falls into the plane determined by *B* and *C*. The last condition is not fulfilled in the device shown, which will have the effect that instead of the irregularity of motion imparted from *A* to *C* by the first coupling being neutralized by the second coupling, it will be doubled. The device will thus not work satisfactorily in any case until you turn either one of the couplings 90°. Supposing the evil just mentioned to be remedied, the angle x is limited by (1) interference of the parts; (2) vibrations caused in the middle section *C*, its motion, unlike that of *A* and *B*, not being uniform. At moderate speed, however, the

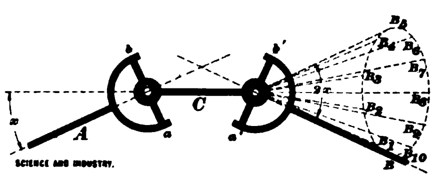


FIG. 2.

angle may be as great as 45°, making a total deflection of *A* against *B* of 90°, all that is ordinarily asked for. (*c*) Depends on the speed. (*d*) By making an agreement with the patentee. (*e*) See (*a*).

***

(379) Will you explain how, in selecting slate, a person can tell the difference between good and bad quality? D. G. W., Boston, Mass.

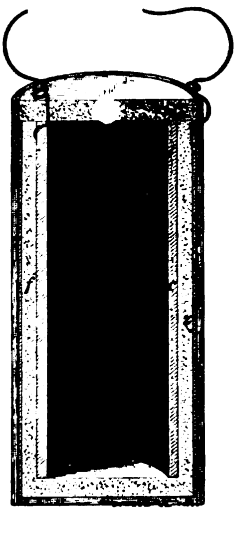
ANS.—When inspecting a quantity of slate, at least six samples, taken promiscuously, should be demanded, and their thickness noted, to determine whether they are up to the requirements of the specifications. When possible, the entire lot should be inspected. The qualifications of good slate are that it shall be hard and tough, not tender or friable at the edges, and should give a sharp metallic ring when struck with the knuckles. It should not split under the slater's tool, should be easily holed without fracture, and should not contain white iron pyrites. Where a slate feels smooth and greasy to the touch, absorbs moisture if placed in water, splits while being holed or trimmed at the edges, breaks when pressed upon, or emits a clayey odor when breathed upon, it is bad and liable to premature decay.

***

(380) Please tell me how to make a dry battery.

H. E. M., Groveland, Mass.

ANS.—The containing vessel should be of cylindrical form and made from sheet zinc, covered outside with pasteboard. The carbon must present a large surface and may be either a cylinder small enough to go inside the zinc vessel without touching, or a bundle of rods, the tops of which are held together by being dipped in melted lead. A bundle of arc-light carbons will answer the purpose. The battery shown in the cut is one using a carbon cell instead of a bundle of rods, but the bundle of rods should work equally well. The space between the carbon *c* and the zinc *z* is filled with a paste *f* made of charcoal 3 parts, mineral carbon or graphite 1 part, peroxide of manganese 3 parts, white arsenic oxide 1 part, a mixture of glucose and dextrine or starch 1 part, hydrate of lime (dry) 1 part; all parts are by weight. Mix, and thoroughly work these into a paste, using a solution composed of equal parts of saturated solution of chloride of sodium (common salt) to which is added $\frac{1}{10}$ volume of a solution of bichloride of mercury and an equal volume of muriatic acid. Seal the cell with a solution made by cooking together, for several hours, equal parts of rosin and paraffin.



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(381) (*a*) Why is the starting rheostat of both series and shunt motors connected to the negative side of the line? (*b*) What would be the result if it were connected to the positive side? I don't understand how the rheostat prevents the armature from being burnt out, if the current passes first through the armature and then through the rheostat. (*c*) How does a rheostat regulate the speed of a shunt motor after full speed has been attained?

F. S., Cleveland, Ohio.

ANS.—(*a*) A starting box need not be connected to the negative side of the line for any particular reason. It is immaterial in which direction the current flows through the rheostat. (*b*) If the starting box were connected to the positive side of the line, the motor would behave exactly as before. The current does not select any portion of a series circuit for an exhibition of its heating properties. The circuit

as a whole, in the case of series motors, armature, field, and starting box, has a definite resistance, and the current reaches the same strength in all parts of the circuit at the same instant. Shunt and series motors can be considered as being alike in this respect, as the shunt-field winding does not affect the armature circuit in the least. (*c*) A starting box is used only to bring the motor gradually up to full speed, and *should not be used for speed regulation* after that. If variation in speed is required, a regulating rheostat should be placed in the field circuit, and another in the armature circuit. Inserting resistance in the field circuit will *raise* the speed of the motor; inserting resistance in the armature circuit will *lower* the speed of the motor. In the case of a constant-current series motor, the speed of the motor can be varied, either by cutting in or out sections of the field or by shunting it with a variable resistance. In any case a reduction in field strength will cause an increase in speed of the armature. See article "Connections for Continuous-Current Motors," in November, 1899, number of this magazine.

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(382) (*a*) What is the greatest number of feet a centrifugal pump will lift water, and to what height can it be discharged? (*b*) Is there any workshop method for distinguishing steel from iron, or is a chemical analysis necessary? (*c*) It is claimed that telephone communication can be made through bimetallic wire when one-half mile of the latter is lying in mud. Does this apply to circuits with earth return, and if so, how can this property be explained? (*d*) Would talking be clearer over No. 8 than over No. 12 iron wire, or would the increased disturbance resulting from external and earth currents eliminate the advantage of the lower resistance of the larger wire? E. H. L. C., Caracas, Venezuela.

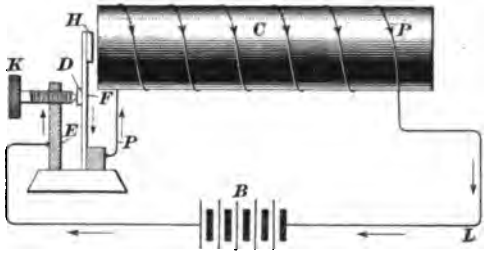
Ans.—(*a*) The greatest height at which a centrifugal pump should be placed above the water supply is about 25 feet; the pump will draw water to this height only under very favorable conditions. The maximum total height above the level of the supply to which water may be raised by a single centrifugal pump is probably not greater than 60 or 75 feet. Practically, it is found that pumps cannot be worked successfully under total heads of more than 40 or 50 feet, and under lifts of this amount their efficiency is rather low. (*b*) The simplest test for distinguishing between wrought iron and steel is to break the specimen by nicking lightly and bending it carefully across the grain. The structure will thus be shown quite clearly, and if the specimen is wrought iron, the fracture will present a rather coarsely fibrous appearance, due to the intermixture with the iron of threads of slag; while steel, depending on its composition and quality, will show either a fine silky or a more or less coarsely granular or crystalline fracture. The above test is, however, not a conclusive one. If the specimen is not broken in just the right way, it may show a coarse crystalline fracture, even if the material is a fine grade of wrought iron or soft steel. The slag may also be so thoroughly worked out of wrought iron, especially if the specimen is a small one, as to give it a fracture very much like that of soft steel. A somewhat more conclusive test is to etch a smooth section of the specimen with a strong acid; the acid will eat away the metal, and, if the specimen is wrought iron, the slag will be easily seen. (*c*) The statement probably referred to a complete metallic wire circuit, in which case almost any wire would work if there were only the one ground. In case of an earth return, if the conductivity of the wire were very high compared to the conductivity of the mud, then enough current might flow through the wire beyond the mud to operate the telephone. A bimetallic wire has a lower resistance than an iron wire, but higher than a copper wire of the same outside diameter; therefore, if the claim you mention is accepted as an advantage of a bimetallic wire, then a copper wire is still more advantageous. (*d*) Except for a very long line, there would be no advantage in using the No. 8 wire over the No. 12. If by external currents you mean currents induced in the telephone circuit by neighboring telephone, electric-light, or street-railway circuits, then the No. 8 would be no better than the No. 12. In regard to earth currents, there would be practically no difference. If your telephone line is noisy use a wire in place of an earth return, and transpose the two wires about every fourth or half mile.

***

(383) (*a*) What size motor will it take to propel a 14-foot skiff at the rate of 5 miles an hour? (*b*) What size and what kind of battery will be required? (*c*) Please tell me how to make this motor. (*d*) Please give me directions for making a 3-inch medical coil that will make a person "dance."

F. S., Palatka, Fla.

Ans.—(*a*) To drive the boat at this speed will require about a ½-horsepower motor. (*b*) Use a storage battery, with the cells so constructed that there will be no possibility of spilling. The size of battery will depend altogether on how long you want to run without recharging. If you wound the motor for 80 volts, you would need about 40 cells of battery, and each cell should have in the neighborhood of 45 ampere-hours capacity for a 10-hour run. (*c*) We cannot undertake to give directions for making



motors in these columns. Address the Riker Electric Motor Co., Brooklyn, N. Y., or the Mianus Electric Co., Mianus, Conn. (*d*) Make two circular hardwood heads about 1½ inches in diameter and ½ inch thick. Press these on the ends of a round core, made up to a diameter of ⅜ inch out of lengths of stovepipe wire 3½ inches long. Insulate the core with two or three thicknesses of heavy paper, and wind on two layers of No. 16 B. & S. double-covered wire, bringing out the ends through the hardwood head. Cover this primary coil with four thicknesses of heavy paper of good quality, and then wind the remainder of the spool full of No. 36 B. & S. double-covered wire. Put a layer of paper between every four or five layers of wire, and attach the terminals of the secondary coil to binding posts. Arrange an ordinary contact maker at one end of the coil. The figure will show you how the battery is connected in the primary, and will also show the construction of the contact maker. *C* represents the core; *H* is a small piece of iron mounted on a flat spring *F*; *D* and *K* form the contacts, so that when *H* is drawn up the circuit is broken, and the arm continues to vibrate, thus making and breaking the circuit. The secondary, or fine-wire, coil is not shown.

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(384) On page 90 of the "Mechanics' Pocket Memoranda," third edition, there is given the development of the slope sheet of a boiler. (*a*) In Fig. *C*, should the distances $J m'$, $m' o'$, $o' p'$, etc. be equal to the lengths of arcs $J m$, $m o$, $o p$, etc., and if

so, what method should be used? (*b*) On page 92, should the radii *a b*, *b c*, etc., in Fig. *F*, be equal to arcs of the same name in Fig. *C*? (*c*) How is the thickness of the metal allowed for? (*d*) In finding the volume of a spheroid, why is it necessary to square the revolving axis? E. J. S., Camden, N. J.

ANS.—(*a*) Yes; the development is most easily accomplished by the method shown in Fig. 1. Corresponding points are designated in this illustration by letters similar to those in the "Mechanics' Pocket

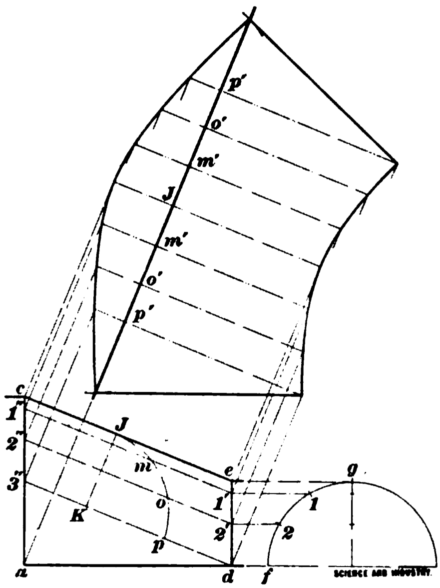


FIG. 1.

Memoranda." (*b*) Yes, after allowing for the thickness of the metal. (*c*) As in Fig. 2; lay off the stretchout $p\,o'\,m'$, etc. to p', and make $p'x$ equal to the required allowance. After describing the arc as shown, draw $p'\,p''$ and corresponding parallels from each point on the stretchout. Draw $p\,p''$ and measure each arc in the pattern on this line. All distances in the direction of curvature should be treated in a similar manner, whether the development is accomplished by means of parallel lines, as on page 90, or by triangulation, as on page 92. (*d*) Volume, or cubical dimension, is an expression implying extension in three directions. Obviously, three linear factors must be employed for all solids, as in the case of the cube, whose volume is the product of its length, breadth, and thickness.

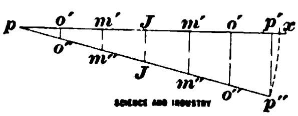


FIG. 2.

When the volume of the spheroid is sought by the formula $\frac{1}{6}\,\pi\,a^2\,A$, it is apparent that one dimension is represented by A, the fixed axis, and it is therefore necessary to take the revolving axis a twice as a factor—or, in other words, to square the revolving axis—in order that the extension of the solid in three directions may be accounted for. The product thus obtained, as in the case of the sphere, is then multiplied by the constant $\frac{1}{6}\,\pi$, or .5236, to include only such dimensions as are enclosed by the curved surface of the solid.

(385) (*a*) Are licensed engineers and pilots required on steam launches of all sizes? (*b*) Do launches operated by gasoline, naphtha, and electricity require licensed pilots and engineers? (*c*) Are licensed engineers required for stationary steam engines? (*d*) Are graduates from institutes of technology and holding the degree of M. E. required to pass examinations before practicing in their profession? H. I. W., Cresskill, N. J.

ANS.—(*a* and *b*) For steam launches, not exceeding 10 tons register, a special engineer's license is required, if the boat comes under the jurisdiction of the Board of Supervising Inspectors of Steam Vessels. Any person may be licensed as engineer on vessels propelled by gas, fluid, naphtha, or electric motors, of 15 tons gross or over, engaged in commerce, if, after examination in writing, the applicant is found to be duly qualified. For small pleasure boats coming under the supervision of the Board, a special pilot's license is required. The owners of such vessels may hold this, and also the special engineer's license, if found duly qualified on examination. (*c*) Some states and quite a number of cities require the licensing of stationary engineers. (*d*) No; unless they wish to become marine engineers. Then, the time spent at college is, by law, declared to be the equivalent of two years' actual sea service; three years' sea service is required before an applicant can be examined. Ordinances and laws relating to the licensing of stationary engineers make no allowance for time spent at college; at least not to our knowledge.

***

(386) (*a*) Why is water sucked from the boiler into the cylinder of an engine when working under a heavy load, the boiler being full of water and the steam pressure high? (*b*) Suppose a boiler, having a hot fire under it, to have evaporated all the water: would the steam remain in the boiler? (*c*) If cold water were now pumped into this boiler would it explode? (*d*) If so; why? P. K., St. Louis, Mo.

ANS.—(*a*) When the engine works hard, a great deal of steam must be supplied to it. To supply this steam, the water must be evaporated; that is, steam must be formed and rise from the water very rapidly. The bubbles of steam that rise from the surface of the water carry up particles of water in the form of a spray, and this water is carried by the current of steam through the pipe and into the cylinder. If the water in the boiler is low, and there is a large steam space, the current of steam through the steam space will not be so rapid and will carry less water to the pipe. (*b*) Some steam would remain in the boiler unless air or some other gas was allowed to enter and drive the steam out. (*c*) There would be danger of causing an explosion, especially if the plates were allowed to get very hot. (*d*) The cold water would cause the hot plates to contract very rapidly and unevenly, thus producing severe stresses that would be likely to fracture them. Also, when the water touched the hot plates, great quantities of steam would be suddenly formed and a heavy pressure produced.

***

(387) Will you tell me how to galvanize small iron bolts, nails, etc.? J. K. M., Charleston, Wash.

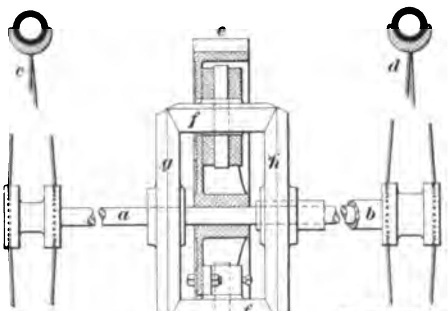
ANS.—The articles to be galvanized are first thoroughly cleansed by placing them in a pickle, next rinsing them off, then submerging in a solution of zinc salt, and connecting with the positive pole of a battery. Zinc plates connected with the negative pole are suspended in the fluid and the electric current turned on. The surface of zinc produced in this manner may be given a metallic luster by quickly moving the article over a fire. An excellent pickle for iron is obtained by mixing 10 quarts of water with 28 ounces of concentrated sulphuric acid, dissolving 2 ounces of zinc in the mixture, and adding

12 ounces of nitric acid. This mixture makes the iron object bright, while they become black in dilute sulphuric acid. To cleanse badly rusted iron objects without attacking the iron itself, it is recommended to pickle them in a concentrated solution of chloride of tin, which, however, should not contain too much free acid, as otherwise the iron is attacked. The duration of the pickling depends on the thickness of the scale, etc. that is to be removed. The pickled articles are rinsed in cold water, then immersed in hot water, and dried in sawdust. In order to neutralize the acid remaining in the pores, it is advisable to make the rinsing water alkaline by the addition of caustic soda. The following zinc bath is recommended: Sulphate of zinc, 2.8 ounces; ammonium sulphate, $1\frac{3}{4}$ ounces; sal ammoniac, 11 drams; water, 1 quart. Dissolve the salts in the heated water and use the bath at 68° F. The electric current should only be slightly greater than necessary for the decomposition of the bath; the most suitable tension is 2.8 to 3 volts. As anodes, rolled zinc sheets of not too small dimension are to be used.

***

(388) (*a*) Kindly give me a sketch and explanation of a compensating gear as applied to the automobile. (*b*) Show me how the different motions of the wheels in turning the vehicle are obtained without either wheel grinding in the ground.
J. E. C., Wheeling, W. Va.

ANS.—(*a*) The accompanying sketch is a diagram showing the principles of construction of the compensating gear usually applied to automobiles. In this sketch, *a* is a shaft to which the wheel *c* is keyed. On this shaft is a sleeve *b* to which the wheel *d* is keyed. A spur wheel *e* is driven by the motor; this wheel revolves freely on the shaft *a*, and carries two bevel wheels *f*, *f* that revolve on pins fixed to the arms or web of the wheel. The bevel wheels *f*, *f* are in mesh with two bevel wheels *g* and *h*; *g* is keyed to the shaft *a*, and *h* is keyed to the sleeve *b*. Now, if the vehicle is running straight ahead and each of the wheels *c* and *d* travels the same distance,



the whole mechanism revolves together. If, however, one of the wheels (*c*, for example) is held, while *d* is free to move, the spur wheel *e* will revolve on the shaft *a*, the bevel wheels *f*, *f* will roll on *g*, and by their motion will drive the wheel *h* and with it the sleeve *b* and wheel *d*. By this means either wheel may be held stationary, or one wheel may move at a slower rate than the other, and at the same time both wheels will be driven from the motor with the same amount of force. (*b*) The above description will show how the turning motions referred to in your question are obtained.

***

(389) What must be the capacity of a tank made of $\frac{1}{16}$-inch plates to support a person weighing 150 pounds in water, as shown by enclosed sketch (Fig. 1)?
A. M. J., Los Angeles, Cal.

ANS.—This depends on the form and dimensions of the tank, and the material of which the tank is made. Let the tank be a prismatic box having a cross-section as shown in Fig. 2, and having two covers, each b inches long, $(d + 2t)$ inches wide, and t inches thick. Also,

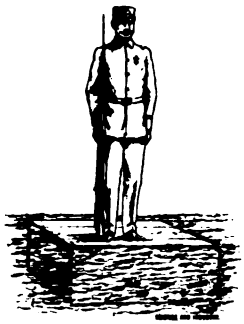


FIG. 1.

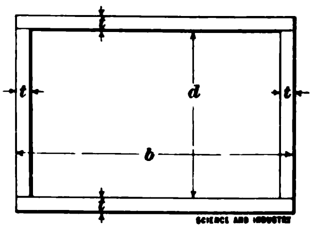


FIG. 2.

let h = height of tank (not including covers); w = weight of the material per cubic inch, in pounds; and w' = weight of the water per cubic inch, in pounds. Then, the box will be just flush with the surface of the water, when the following equation is satisfied:

$$2\,t\,w\,[h(b + d) + b(d + 2t)] + 150$$
$$= b\,w'(d + 2\,t)\,(h + 2\,t).$$

By assuming any three of the four dimensions, the other may be found from this equation, and then the contents v of the tank is given by the formula

$$v = d\,h\,(b - 2\,t).$$

***

(390) (*a*) What is thorium, or thorite? (*b*) Which is used in making incandescent mantles for lamps. and how are these mantles made?
C. W. S., Milwaukee, Wis.

ANS.—(*a*) Thorium is one of the rare elements; it occurs in the mineral thorite, which is composed of thorium oxide and silica. Thoria ThO_2, the oxide, is used in the manufacture of incandescent mantles. (*b*) The actual details regarding the manufacture of these mantles are unknown to us.

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(391) Will you kindly describe the latest developments in testing storage-battery cells and plates by using the cadmium test plate?
H. A. K., Hartford, Conn.

ANS.—You will find this method of testing battery cells described in the New York "Electrical Engineer," Vol. 23, page 454. The plate of cadmium is mounted in a hard-rubber frame and immersed in the electrolyte. The E. M. F. is then read between the plate and the positive and negative plates of the cell. During the charge the cadmium plate reads negative to the negative plate of the battery until the cell is nearly charged, when the reading should be zero. The charge should be continued until the cadmium reads about .2 of a volt, positive to the negative plate, while charging at the normal rate. In using the plate it should be shaken occasionally to remove any bubbles of gas that may have formed on the surface, and the plate should be washed with water every time it is taken from the cell.

(392) (*a*) Show how to find, graphically, the correct radius of a Stephenson link, by scribing the outlines of the link on a board and then finding the radius with a pair of trams. (*b*) If the eccentrics of a link motion are properly set and the link is raised to a central position and steam is turned on, will the engine run in either direction if what is known as "open rods" are used? (*c*) In a crossed-rod link motion, does the valve occupy a central position when the link is raised to a central position?

F. W. G., Rockmont, Wis.

ANS.—(*a*) If the eccentric rod and strap are at hand, you can first get from them the link radius to within

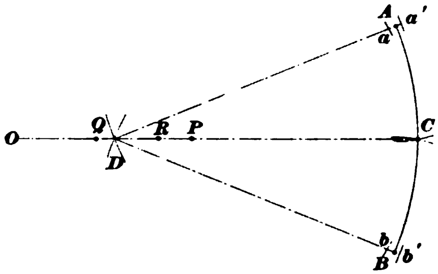

FIG. 1.

an inch or so. If it is short enough (say not more than 3 feet) to enable you to handle the trams yourself, you can find the center of the arc by trial. Let $A B$, Fig. 1, represent the arc of link, as marked out on the board. Bisect $A B$ at C, and with any convenient radius and A and B as centers, strike two arcs intersecting at D. Join $C D$ and produce to O; the center of the link arc will lie somewhere on $C O$. Set your trams to $P C$ and try the arc over. If the tram point, while touching arc at C, falls short of A, B, as at a, b, your trial radius is too short. Next try $Q C$. If, now, the point falls beyond the arc at a', b' while touching at C, the radius is too long. Using good judgment, the next trial radius $R C$ may be the correct one. If the radius is too long for the foregoing method to be conveniently applied, try the following: With a radius about as shown in Fig. 2, strike arcs A', B' from the ends A and B of link, respectively. Join $A A'$ and $B B'$ and bisect the chords thus found at A'' and B''. From the ends A and A' of the chord $A A'$ describe, with any convenient radius, short arcs intersecting at A'''; do the

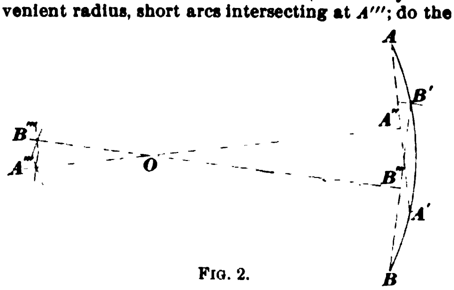

FIG. 2.

same for the chord $B B'$, obtaining the point of intersection B'''. Join $A'' A'''$ and $B'' B'''$, intersecting at O. O will be the center of the circle of which the arc $A B$ is a part; in other words, the distance from O to any point on the arc is the radius required. (*b*) We should say not. Your words "properly set" leave room for quite a little speculation. Also, you do not say anything as to position of cranks when attempting to start. Although the engine, with normal valve setting, would not be likely to start in any position, yet it would be less able to do so in some positions than in others. See reply to inquiry No. 124, in June issue of "The Mechanic Arts Magazine." If the reach rod were too long in the first place and the valve gear is very much worn and also is set with excessive full-gear lead, then, of course, the lead (which constitutes the port opening in mid-gear) will be increased. But you must bear in mind that this occurs when that particular crank is on dead center and has, therefore, no turning effect; true, the other crank is at 90°, but its port will be closed to steam. (*c*) This part of the question admits of no definite answer. It all depends on where the crank is. In the case both of open and of crossed rods, there are two crank positions in every revolution wherein the valve is in the center of its travel.

***

(393) In the factory in which I am employed there are two 500-volt generators: one, 100 kilowatt; and the other, 80 kilowatt. These generators are 1,500 feet apart; they are driven by different engines, and are in charge of different persons. (*a*) Can they be worked together, both feeding into the same mains? (*b*) If so, how?

D. C. L., Springfield, Ohio.

ANS.—(*a* and *b*) It would not be an easy matter to operate machines in parallel under the conditions you name; you would find it very difficult to make each machine take its proper share of the load. A better way would be to split the wiring system into sections, so that each dynamo would have its own particular section to supply with current and would work independently of the other. This would be a much more satisfactory way than to attempt to operate the machines in parallel under the conditions.

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(394) (*a*) I run an Edison 40-kilowatt, 110-volt shunt-wound dynamo, and wish to know if there would be any danger of damaging the dynamo should the field switch be opened when the machine is carrying a load of about 240 amperes. We frequently have short circuits on the line; and as we have no fuses or circuit-breakers, will it be safe to open the switch? (*b*) I have a small magneto generator such as are advertised as "hand-power dynamos," and wish to wind the armature (formerly wound with No. 40 wire) so as to get a direct current at high E. M. F. What size wire should be used in rewinding it?

H. B. G., Idaho Springs, Col.

ANS.—(*a*) It is not generally advisable to open the field circuit of a shunt-wound dynamo when the machine is in operation. There is danger of damaging the insulation of the field coils because the high induced E. M. F., generated when the circuit is suddenly broken, is liable to puncture the insulation. It would be far better to have some kind of main switch in the circuit, that is, a switch of the knife-blade variety that will be fully capable of breaking 240 amperes without undue arcing at the contacts. No dynamo should be installed without a main switch of this kind, and if you have no such switch it would certainly pay to put one in. If you so desire you can break the field circuit without any danger if you first cut in the rheostat so as to reduce the field current to the lowest possible amount; it would then be quite safe to break the circuit for a machine of this voltage, but such a method of throwing the load off the machine should be looked on as a makeshift, and the best way would be to have the machine properly equipped with a main switch and also with a circuit-breaker. (*b*) If you wish direct current for this machine, you must provide it with a commutator. We do not know what kind of armature your machine is provided with, so we cannot tell what kind of commutator is suitable. Probably a two-section commutator, such as is used on many magneto machines, would be suitable in this case. If you want a high E. M. F., you must wind the armature with a large number of turns of fine wire.

If your armature was already wound with No. 40 wire, we do not see how you can make things much better as regards E. M. F. unless you increase the speed of your machine, because it would not be practicable to wind the armature with a wire any finer than No. 40. If you put on any larger-sized wire you will not be able to get on as many turns, and hence the armature will not generate as high an E. M. F. as it did with the old winding.

***

(395) (*a*) What is conceded to be the best method of flanging joints on wrought-iron steam pipes as large as 12 or 14 inches, carrying a pressure of 140 pounds? (*b*) Is it necessary to peen the ends of the pipe when flanges are screwed on and fit iron to iron? (*c*) Is there such a thing in steam fitting as a *screwed flanged joint peened?* (*d*) Does the peening of a wrought-iron pipe crystallize the material and weaken it? C. E. W., Rankin, Pa.

ANS.—(*a*) The rules and regulations of the Board of Supervising Inspectors of Steam Vessels specify that all lap-welded or riveted wrought-iron or steel steam pipes over 5 inches in diameter shall be flanged as follows: The depth of the bore of the flange, measured in the direction of the axis, shall not be less than one-half the diameter of the pipe. The bore is to be bored slightly tapering, being largest at the face of the flange. The end of the pipe is to be expanded to fit the tapering hole, and then beaded over into a recess into the face of the flange. In addition, good and substantial rivets are to be put through the hubs of the flanges and the pipe. The hub of the flange must project at least 2 inches from the back of the flange. With steam pipes up to 5 inches in diameter, the flanges may be screwed on. Cast-iron flanges are prohibited. While the above rule applies only to boilers on steam vessels, we believe it to be good practice to follow this rule in stationary work. (*b*) No. (*c*) Not that we know of. (*d*) To a certain extent the material at the bead is weakened, especially when the beading is done by an unskilled workman. However, the holding power of the flange is increased by beading the end of the pipe into a recess in the face of the flange.

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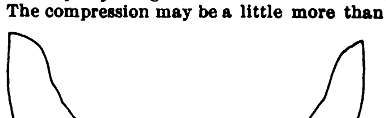
(396) (*a*) Please give me your opinion of the accompanying indicator cards, taken from an 18″ × 42″ Corliss engine, running 90 R. P. M.; boiler pressure, 80 pounds per square inch; scale of indicator spring, 60. Exhaust steam is used for heating purposes. In my opinion, there is too much lead and compression, and the back-pressure line is not high enough. (*b*) What percentage of the coal do you think could be saved by a proper adjustment of valves and eccentric? L. L., San Francisco, Cal.

ANS.—(*a*) The valves seem to be pretty well set, and, in our opinion, there is little chance for improvement by adjusting either valve rods or eccentric. The compression may be a little more than is



needed, but if the engine runs smoothly we would feel well satisfied to leave it as it is. We are unable to see any reason for wanting a higher back pressure; engineers generally try to keep the back pressure as low as possible, and the result shown by your cards is very satisfactory. The worst feature shown by the cards is the very early cut-off, which gives an expansion line running below the back-pressure line, as shown by the loops *a*, *a*. This fault is due to the light load carried by the engine, and not in the least to the valve setting. The remedy is either to use a lower boiler pressure or run the engine slower. By making either of these changes, cut-off will be made to take place later, and the pressure in the cylinder at the end of expansion may be kept above the back-pressure line, and the loops *a*, *a* shown by the cards, prevented. Such a change will probably cause a reduction in the loss of steam by cylinder condensation, with a consequent increase in economy. It will also make the engine run more smoothly. (*b*) It is very difficult to make an estimate of the percentage of coal that could be saved.

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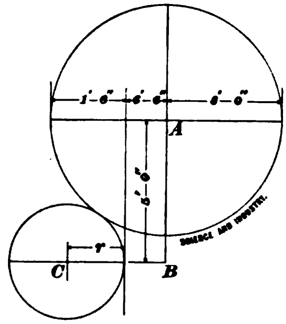
(397) If possible, kindly solve this problem, mathematically, for *r*, from the information given. F. J. W., St. Louis, Mo.



ANS.—We have

$$\overline{AC}^2 = \overline{AB}^2 + \overline{BC}^2 = 5^2 + (6\tfrac{1}{2} + r)^2.$$

Also, since the circles are in contact,

$$AC = 8 + r;$$

which gives $\overline{AC}^2 = (8 + r)^2.$

Equating these two values of $\overline{AC}^2$, we have

$$(8 + r)^2 = 5^2 + (6\tfrac{1}{2} + r)^2;$$

whence, $r = 1\tfrac{1}{12}.$

***

(398) (*a*) Why may not gasoline be exploded in a large closed reservoir, from which the gas under pressure may be drawn for use in an ordinary engine, as steam is now used? (*b*) If such a plan were practicable, how much of the energy would be lost by radiation of heat from the reservoir? (*c*) Is the loss of heat, due to the cooling of the cylinder of an ordinary gasoline engine by a water-jacket, avoidable? (*d*) Does the action of a gas or gasoline engine depend on the heat of the explosion, or on the force of expansion? C. F. J., Washington, D. C.

ANS.—(*a*) The chief objection to such a method seems to be that it would involve an outlay very much greater than the present method of exploding the gas in the cylinder of the engine, while there would be little, if any, gain in economy. There are also some practical difficulties that would have to be overcome in order to make such a method a mechanical success. (*b*) A reservoir might be constructed in which the loss of heat by radiation would be very small. It would, however, be very difficult to construct a reservoir that would withstand the high temperature developed by the heat of the combustion of the gas. (*c*) If the cylinder were not cooled, it would be impossible to keep the piston lubricated, and the cylinder, piston, and valves would quickly be destroyed. The same difficulty would be met in attempting to use gas at a high temperature from a reservoir separate from the cylinder. (*d*) The mixture of gas and air explodes and burns very rapidly,

thus developing a great amount of heat, which produces a high pressure. The action of the engine depends on the expansive force of this hot gas and air.

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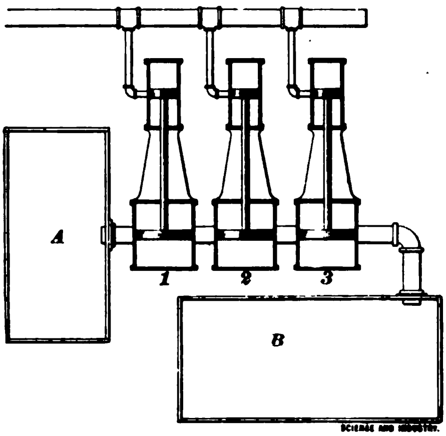
(399) Enclosed sketch represents three steam pumps; the area of each steam pipe is 1 inch; the steam pressure is 100 pounds gauge; pump No. 1 takes water on level with pump valves through pipe of 2-inch area, and delivers to pump No. 2; No. 2 delivers to No. 3; and No. 3 delivers to receiving tank. Assuming that each pump delivers at 50 pounds pressure, what will be the pressure on the tank? E. A. S., Worcester, Mass.

ANS.—Assuming that each pump is capable of delivering the water to the next at a pressure of 50 pounds per square inch greater than the pressure at



which it received the water from the preceding pump, and that the level of the surface of the water in the suction tank *A* is the same as the level of the surface in the receiving tank *B*, the three pumps as arranged will be capable of forcing water into the receiving tank against a pressure of $3 \times 50 = 150$ pounds per square inch.

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(400) (*a*) Two duplex steam pumps, delivering the same amount of water in a given time under exactly the same conditions, have the same dimensions in all respects, except that the diameters of the steam cylinders of pump A are 10 inches and of pump B 14 inches; would not pump B use more steam than pump A? (*b*) By increasing the steam pressure for pump B, would the same amount of steam as is used by A do the work at the lower pressure? (*c*) What is the purpose of the very slight incline of steam-pump cylinders and piston rods, the water cylinders being a very little lower than the steam cylinders? W. F. B., Wayne, Pa.

ANS.—(*a*) To do the same work, the effective pressure of the steam in the cylinders of B would be less than in the cylinders of A, the ratio being nearly inversely as the squares of the diameters; that is, as $10^2 : 14^2 = 100 : 196$, or $1 : 2$, nearly. At the same time, the volume of steam used by A would be less than the volume used by B, the volumes used by the two being nearly directly proportional to the squares of their diameters. B would therefore use nearly twice as many cubic feet of steam as A, but at a pressure only one-half as great. The weight of a cubic foot of steam at the lower pressure will, however, be more than half as great as at the higher; the weight of the steam used by B will therefore be somewhat greater than that used by A. Assuming that A will do the work with steam at a pressure of 100 pounds per square inch, gauge, nearly 16 per cent. more pounds of steam would be required by B to do the same work at a pressure one-half as great. The actual difference would probably be even greater than this. (*b*) No. (*c*) We have never seen a pump with the peculiarity of construction you mention, and do not think they are purposely so made.

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(401) (*a*) Please give the name of the best work on setting the valves of Corliss engines. (*b*) Can you give me any information in regard to the Nordberg automatic cut-off engine? (*c*) Please give and explain a diagram for setting the valves of this engine. W. F., Montreal, Can.

ANS.—(*a*) "Handbook of Corliss Steam Engines," by F. W. Shillitto, Jr., is an excellent work. It may be obtained from The Technical Supply Company, Scranton, Pa.; price, $1.00. (*b* and *c*) The Nordberg Manufacturing Company, Milwaukee, Wis., are the builders, and can give you any information regarding its construction and methods of setting the valves that you may need.

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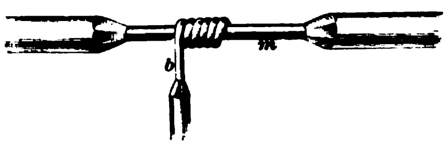
(402) (*a*) How can I make resistance coils for cutting down a 55-volt 10-candlepower lamp to give 2 candlepower and 5 candlepower? (*b*) Please recommend a book, written in simple language, giving instruction on telephones and their construction. (*c*) Can a commutator for alternating currents be used to make an alternating current into a direct current? (*d*) Please show a good way to splice a branch wire to an intermediate point on another wire. C. S., Oak Park, Ill.

ANS.—(*a*) Make a rheostat composed of 75 feet of No. 24 tinned iron wire. Tap it at points 5 feet apart. If one-third of the rheostat is included in the circuit, the lamp will give, approximately, 5 candlepower. For determining the point at which a light of 2 candlepower is emitted, you had better have recourse to experiment with the rheostat. (*b*) "Telephones: Their Construction and Fitting," by F. C. Allsop; price, $2.00. This book may be obtained from The Technical Supply Company, Scranton, Pa. (*c*) Yes: it is known as a rectifier. (*d*) Bare the main and branch wires as shown in the figure, being careful not to nick the wires in so doing. Wrap the branch wire *b* around the main wire *m* and solder thoroughly,



using resin as a flux. After soldering, the joint should be carefully taped, so that the insulation around the joint will not be defective. This taping should be put on carefully and neatly, as it is a more difficult matter to tape such a joint properly than a plain Western Union joint.

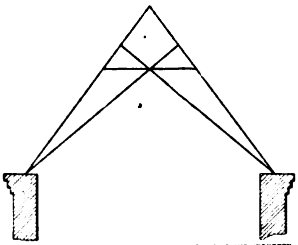
***

(403) In the building in which I am employed they are putting in some fireproof vault doors. These doors have been on the ground for some time, as we were not quite ready for them. On proceeding to put them in position, however, it was found that one or two of them had burst at the corners. Can you explain the cause of this?

F. S. S., Trenton, N. J.

ANS.—Vault doors of steel are sometimes filled in between the plates with a mortar composed of a fireproofing substance, and when these doors have been in a wet place this filling has been known to absorb moisture, which causes it to expand and burst the metal frame. Several such cases have been known, and very likely a similar cause applies to the case you mention.

(404) Will you inform me through your inquiry columns in regard to the following questions: (*a*) What form of plate, and what method of anchoring same to brickwork, is usually employed for a church constructed as designated in the accompanying figure? (*b*) What is the best method of furring for the wainscoting and base finish in the same



SCIENCE AND INDUSTRY.

building, the plastering to be laid on the brick wall? (*c*) Do you consider the Morse steel wall tie a good tie to use for bonding an 8-inch outside wall and a 4-inch inside wall with a 2-inch air space between; and how frequently should they occur in the wall?
A. M. W., South Haven, Mich.

ANS.—(*a*) It is usual to make such a plate of, say, two thicknesses of 2″ × 8″ or 12″ spruce, laid one on top of the other, spiked together, lapping at the corners, and bedded in hair mortar. Anchoring is unnecessary if the trusses are properly tied so as to exert no thrust, although the plate may sometimes with advantage be secured sufficiently to keep it in place during erection. (*b*) Where wainscoting is formed with vertical lining, it is customary to secure it to three nailing strips or grounds, one at the top, one at the bottom, and one at the center. Wainscoting, when paneled, does not require the central ground, as the framing is stiff enough without it. The baseboard is attached to a ground about $\frac{7}{8}$ in. × 2 in., placed $\frac{1}{2}$ inch from the top edge and to a nailing strip on the floor. If the base is over 6 inches wide, it is apt to "dish" during shrinkage, if not supported at the back. To this end, upright pieces, called *soldiers*, are placed at intervals of 16 inches. (*c*) The Morse steel ties make a secure job when placed about every third brick in the length, and in each fifth course in the height. We do not know the conditions you have to deal with, but would suggest that the inside wall be the 8-inch one, as the weight of the floors is carried by it.

***

(405) I am building a number of sheds and outbuildings near a railroad, and would like to know of some cheap fireproof paint or wash that I could apply.
M. B. D., Tyrone, Pa.

ANS.—Temporary wooden structures, such as sheds, etc., may be made more or less fire-resisting by applying alternate coats of silicate of soda and lime wash.

***

(406) Can you inform me of a good method by which I can test the quality, or holding power, of glue?
C. C. D., Philadelphia, Pa.

ANS.—If a good quality of glue is used, two pieces of white pine, glued together, and allowed to set for a period of 24 hours, will break anywhere but at the joint. For instance, take two pieces of white pine, 1 in. in thickness and 12 in. long, gluing them together at the edges, and placing them in a vise with the joint at the jaws. If the projecting edge is struck a blow and the wood breaks instead of the joint, the quality of the glue is assured. Also, a chisel or wedge, driven in the end grain at right angles to the joint line, should rend the wood before destroying the junction.

(407) What advantage is gained by placing felt paper between a tin roof and the sheathing?
F. H. S., Easton, Pa.

ANS.—It prevents the possibility of condensation on the under side of the tin, which, when it occurs, causes rapid corrosion, as the under side can never be properly protected by painting. It also provides a cushion for the tin, so that where there is any traffic over the roof, the edges of the sheathing or knot holes do not cause ridges and projections that rapidly wear through and cut the tin.

***

(408) I have charge of the storeroom for a concern retailing plates and rolled sections in connection with their other business of ornamental ironwork. Each month we issue a stock list of rolled beams, etc., giving their weights and sectional areas. Our stock, however, is varied, and at times we have difficulty in determining the sectional area of the rolled shapes, and cannot spend the time to calculate them; the weight per foot we readily ascertain by weighing, and dividing by the length. Can you give me a simple method by which the sectional area of any rolled shape may be determined?
T. S. P., Brooklyn, N. Y.

ANS.—Having obtained the weight per foot of the beam in pounds, the area of the section may be obtained by dividing by 3.4, which is the weight of a bar of structural steel 1 foot long and 1 square inch in section.

***

(409) I understand that a large percentage of the commercial white lead is adulterated. (*a*) What substance is principally used in adulterating it? (*b*) How may the purity of white lead be determined?
A. C. L., Portland, Me.

ANS.—(*a*) Sulphate of baryta, a white earth, is the most common adulterant; it is a dense white substance very much like white lead in appearance. It absorbs very little oil, and may be detected by the gritty feeling it produces when the paint is rubbed between the finger and the thumb. (*b*) The purity of white lead may also be tested by exposing a portion of it to heat, and reducing it to the metallic state; by weighing it before and after the reduction the percentage of moisture and impurities may be determined.

***

(410) In building brick chimneys or other brickwork subjected to heat, is it best to use lime or cement mortar?
P. T. R., Athol, Mass.

ANS.—The latest opinion of experts on this subject indicates that the use of cement in fire-resisting walls is not to be recommended.

***

(411) I wish to heat 30 gallons of water in a bath-tub from 50° to 95° F. What length of time and what current will be required with a 110-volt circuit. My idea is to immerse some 16-candlepower lamps in the water.
F. W. H., Tacoma, Wash.

ANS.—An expenditure of 55 watts of electrical energy continuously for 1 hour will raise the temperature of 1 pint of water 90° F., and probably $\frac{1}{2}$ hour will suffice to raise it from 50° to 95° F. You would, therefore, require about 240 lamps to accomplish your purpose. A better plan would be to construct some form of heater, to heat the water while running into the tub. Procure a slab of soapstone, say 6″ × 2″, and wind enough German silver wire on it to give a resistance of, say, 100 ohms. Use No. 24 B. & S. wire. We cannot give exact particulars of apparatus of this nature, not having had occasion to construct any, while the available data to be drawn from are meager. A little experimenting will enable you to make a satisfactory heater. We would suggest that, if the heater on the lines we have laid down does not prove satisfactory, you rewind it with No. 20 or No. 21

B. & S. wire, making the resistance 50 ohms, if the heater in both cases is to be used on a 110-volt circuit.

***

(412) I would like information in regard to concrete made with material other than broken stone. Can you tell me what is usually substituted, and the qualifications of such concrete as to strength and fire resistance? G. N. C., Pottsville, Pa.

ANS.—Besides broken stone the aggregates of concrete may be made of slag, broken firebrick, pumice, or coke breeze. Slag makes the strongest, and coke breeze the weakest, concrete. In tests made with the above concretes, however, it was found that, when they were heated to a red heat and quenched with water, the first three lost about two-thirds of their strength, while coke breeze, formerly the weakest, was stronger than the other three.

***

(413) (*a*) What is the tensile strength of steel tubing, such as used in bicycle construction? (*b*) Would such tubing be suitable for boiler construction? (*c*) Please give a sketch of an easily made and durable water-tube boiler of about 2 horsepower. A. C. K., Madison, Wis.

ANS.—(*a*) Different makes of tubing have tensile strengths that vary from 60,000 up to 100,000 pounds or more per square inch of section. (*b*) Yes. (*c*) An answer to this question involves a great deal more time and space than can be devoted to it. We do not furnish designs for machinery or engineering appliances.

***

(414) (*a*) In Fig. 1 are given the shape and dimensions of a building lot; the shaded part is built up; what percentage of the lot is built up? (*b*) How many cubic feet capacity has the cylindrical vessel of form and dimensions given in Fig. 2? I attended a civil-service examination a short time ago, and the above were among the problems in arithmetic; I would like to be sure whether or not I answered them correctly. E. H. G., Brooklyn, N. Y.

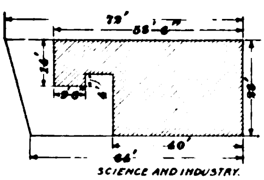


FIG. 1.

ANS.—(*a*) The whole lot being a trapezoid, its area is found by multiplying half the sum of its parallel sides by its altitude; therefore, the area of the whole lot is $\frac{1}{2}(72 + 64)\,28 = 1{,}904$ square feet. The shaded portion is made up of three rectangles, and its area is $40 \times 28 + 9 \times 10 + 9\frac{1}{2} \times 14 = 1{,}343$ square feet. Therefore, for every square foot in the lot there is $\frac{1{,}343}{1{,}904}$ of a square foot built up; and, hence, of every 100 square feet, there is $\frac{1{,}343 \times 100}{1{,}904}$ square feet built up. Thus, the percentage built up is $\frac{1{,}343 \times 100}{1{,}904}$, or $70\frac{1}{2}$ per cent., nearly. (*b*) The dimensions given in Fig. 2 are manifestly wrong; for the width at *A B* is 7 feet 6 inches, while the width at *C D* and at *E F* is 9 feet 4 inches; therefore, we cannot calculate the capacity of the vessel.

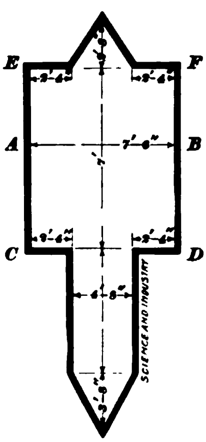


FIG. 2.

(415) I am desirous of constructing a wooden-trough gutter in connection with a box cornice. I would be pleased to have you show how such a gutter may be constructed. A. C., Pulpit Harbor, Me.

ANS.—In Fig. 1 is shown such a gutter as you suggest, in which the trough is formed out of a 4″ × 7″ cedar plank. The details of construction are fully shown, and are self-explanatory. You will observe that the plank is of sufficient depth to allow for the gradual grooving, so as to insure a proper pitch of the gutter. Such a gutter would be more permanent by lining it with copper. By nailing a strip of hoop iron on the fillet at the drip of the gutter and clasping over it the edge of the copper, a neat edge can be secured without face nailing. The copper can then follow the profile of the gutter and facia, and pass up under the slating a couple of inches. You will observe that the outer edge of the gutter is in line with the sheathing of the roof, so that the crown mold can be carried up the rake of the gable in proper form, as shown in Fig. 2.

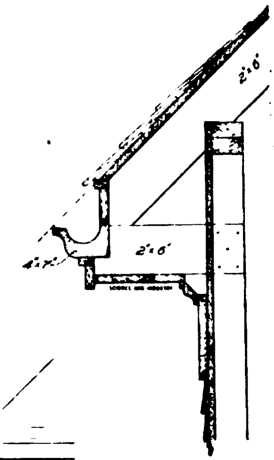


FIG. 1.

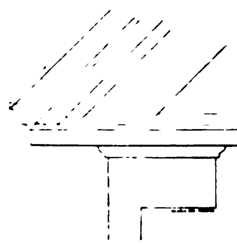


FIG. 2.

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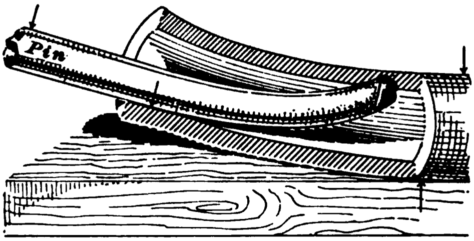
(416) I wish to make an induction coil for X-ray work, using 10 pounds of No. 34 B. & S. double cotton-covered wire. Please give me the following information: (*a*) Diameter and length of primary core: number of turns and size of wire for primary. (*b*) In how many sections should the secondary be wound? Give inside and outside diameter and width of section. (*c*) What length of spark will such a coil give? (*d*) Give size of liquid interrupter to be used with this coil on a 110-volt circuit, and on a battery circuit from 8 to 10 volts. (*e*) Give size and number of sheets of tin foil for condenser. (*f*) What size of X-ray tube should be used? (*g*) Give other information needed to make a good coil. G. J. L., Dayton, Ohio.

ANS.—(*a, b, c, e, g*) To operate an X-ray tube in a satisfactory manner, the coil should be capable of giving a 6-inch spark. Space does not permit us to go into the details of your inquiry in a manner sufficiently full to make the descriptions of practical use to you. You will find all the points you have inquired about in any good book on induction coils. You will find many good points regarding construction in Bonney's "Induction Coils." (*d*) You will find instructions for making a Wehnelt liquid interrupter for use on 110-volt circuits in "The Steam-Electric Magazine" for May, 1899. You cannot operate a liquid interrupter on 8 or 10 volts, so that if you wish to use a battery you will have to connect a number of cells in series so as to get a higher voltage. (*f*) A 5- or 6-inch tube, i. e., a tube designed for a 5- or 6-inch spark.

(417) I was much interested in the article entitled "The Art of Joint Wiping," which appeared in "The Building Trades Magazine" for October. It is stated that considerable damage is done to the inside of the lead pipe that is being straightened in Fig. 1. Would you kindly explain to me how this occurs?
J. C. M., Wilkes-Barre, Pa.

ANS.—The damage is done by the point of the bending pin being pressed into the lead as shown in the accompanying figure. If you will carefully examine the illustration of the plumber bending the pipe, you will see that he bears down on the end of



the pipe with one hand and on the end of the bending pin with the other. This action produces forces whose directions are shown by the arrows in the accompanying figure. The tendency of the bending pin is also to stretch the lead at the under side of the orifice, as shown. Sometimes the pressure on the point of the bending pin is so great that the lead pipe is actually torn apart at this place. A first-class plumber never abuses a pipe in this manner.

***

(418) Will you explain how the dry rot in timber takes place; also, if there is any way by which incipient decay in timber can be detected?
O. S. C., Detroit, Mich.

ANS.—Dry rot is caused by a species of fungus that attacks wood subjected to moist or impure air in a confined space. Such conditions are necessary to the growth of the fungus, as it dies rapidly on exposure to sunlight. The fungus may be visible to the naked eye, or may be microscopic. The spores penetrate the cellular structure of the wood, absorbing the secretionary substances, leaving a mere shell of dry and crumbling tissue. Timber affected with dry rot has a musty smell; the wood shrinks and leaves corduroy furrows; brown spots also appear on the surface. A fine steel pricker mounted with a handle may often be used to advantage in inspecting timber, by pushing it slowly into the timber and noting its resistance. If it enters the timber easily, it indicates a spongy nature and lack of virtue; if with a slipping motion, the timber is damp; if in jerks, there is interior rot or shakes. In good resinous timber it can be inserted, turned, or withdrawn with difficulty.

***

(419) In your November, 1898, issue of "Home Study Magazine," Answers to Inquiries, No. 445, you say in regard to the gas-engine igniter, "wind 88 ounces of 34 S. C." for the secondary. This makes a very bulky coil for the length. Is this weight the dry weight?
L. P. M., Montreal, Can.

ANS.—The weight given in the answer you refer to is the dry weight of the wire. In the answer referred to, the "88 ounces" is a misprint; it should read "8.8 ounces."

***

(420) How do you calculate the offset of a saddle pin in a locomotive? J. W. W., Clifton Forge, Va.

ANS.—We cannot spare the space to go into this matter here. When a full-sized model is not used, the link motion is laid out on the board and the proper offset found by actual construction. Even then a temporary adjustable saddle is put up on the first engine of the class while the valves are being set. When everything is properly adjusted, the position of the saddle pin is noted and the permanent saddle made to suit.

***

(421) (*a*) Please inform me how to construct a bichloride dry cell. (*b*) I have been told that this is the only reliable dry cell for medical batteries. Is this so? (*c*) Is the current in the primary coil of an induction coil faradic? (*d*) How should it be connected in order to use it on a patient?
A. M. D., Cincinnati, Ohio.

ANS.—(*a*) See "Home Study for Electrical Workers," November, 1898, Answers to Inquiries, No. 52. (*b*) There are several makes of dry cells that appear to give satisfaction. (*c*) No; it is intermittent, but always in the same direction. (*d*) By connecting the patient to the terminals of the primary coil, an E. M. F. will cause a current to flow in the shunt circuit through the patient. This E. M. F. is much higher than that supplied by the battery, and is due to self-induction.

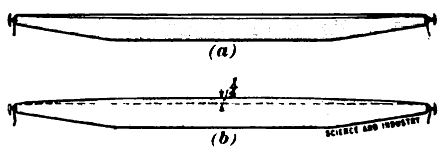
***

(422) I have an iron-armored telephone cable that leads to a securely anchored ship, the bottom of which is copper-sheathed. What I take to be galvanic action has set in and partially destroyed the wires making up the armor. The destructive effect decreases as the distance from the ship increases. The armor wires touch the copper sheath above the water-line. Would separating these help matters any; if not, can you suggest some remedy that will?
H. I. E., Portsmouth, Va.

ANS.—The effect you speak of is due to galvanic action, since the iron sheath of the cable and the copper sheath on the hull form the two plates of a battery, the salt water forming the electrolyte. If you insulate the sheathing of a cable thoroughly from the ship, outside of the water, it should do away largely with the trouble, because there will be no path for the current to flow between the cable and the ship. This would be equivalent to breaking the connection between the zinc and copper plates of a battery, thus preventing the flow of the current and the consequent wasting away of the zinc.

***

(423) I had occasion to make a straightedge, and to test it I stretched a line over the edge, as shown at (*a*) in the accompanying figure. I found, however, upon testing it by another method, namely,



drawing a line with it, and reversing, that it was crowned about $\frac{1}{4}$ inch. Can you explain why my first test failed? W. J. V., Lake Charles, La.

ANS.—By comparing (*a*) and (*b*) of the accompanying figure, you will see that a line can be stretched practically straight over a concave edge, or surface; but when stretched over a convex or crowning surface, it will lie against the surface, and the string will not designate a straight line.

***

(424) (*a*) Explain how to color electric lights an amber, a ruby, and a green. (*b*) What qualifications must a steam fitter have to become a member of the union? H. B. S., Broomfield, W. Va.

ANS.—(*a*) Incandescent lamps may be colored by dipping them in collodion that has been made the

color desired by dissolving aniline dye in it. You should be able to obtain the collodion and the necessary dyeing material at any drug store. (b) Apply to the nearest union.

***

(425) (a) An automatic cut-off non-condensing rolling-mill engine with a 26″ × 48″ cylinder, working with a boiler pressure of 83 pounds, cutting off at one-quarter stroke, and making 65 revolutions per minute, develops 825 indicated horsepower. The steam pipe is 250 feet long and 8 inches in diameter. There is a loss in pressure between the boiler and the steam chest of less than 1 pound. The initial pressure in the cylinder, as shown by the indicator, is but 65 pounds. Is this drop due to too small steam ports? (b) In addition to the rolling mill the engine drives a shaft by means of a 19-inch double belt. What load should the belt be able to transmit, driving from a 16-foot pulley to an 8-foot pulley, a rider on the upper side of the belt being used?

C. A. H., Bridgeport, Conn.

ANS.—(a) It is probable that the drop in pressure is due to the fact that, with a one-quarter cut-off, the valve is opened but a short distance, thus admitting steam to the cylinder rather slowly. This defect might possibly be remedied by giving the steam valves a little more lead. (b) About 100 horsepower.

***

(426) Please give me some information concerning hydraulic elevators: (a) their speed; (b) setting of valves, etc.; (c) safety catches and appliances; (d) rules applying to safety appliances.

ELEVATOR, Washington, D. C.

ANS.—The answer to your question will take more space than we can devote to it in these columns.

***

(427) (a) What number of ampere-turns does it require to operate the ordinary telegraph relay? (b) What is the amperage of the circuit it closes? (c) Is the impedance of one coil having 1,000 turns and a resistance of 200 ohms the same as that of two coils in series, each of 500 turns and a resistance of 100 ohms? The magnets are all of the same size. (d) The capacity of an aerial telephone line, No. 16 B. & S. copper wire, is supposed to be about .0083 microfarads per mile, wire to wire. In calculating the capacity of a line, should one or both sides of the circuit be multiplied by this figure? (e) Do metallic elements combine chemically, as in brass, for instance? (f) Please tell me how to find the resultant of two forces acting in different directions with respect to each other. C. J. E., Chicago, Ill.

ANS.—(a) The ordinary (150-ohm) relay works best with 172 ampere-turns. (b) Usually $\frac{1}{4}$ ampere. (c) No. The impedance of a circuit possessing simple resistance and self-induction, only, is given by the expression,

$$\sqrt{R^2 + (2\pi n L)^2},$$

where R = resistance;
π = 3.1416;
n = frequency or number of complete alternations per second;
L = coefficient of self-inductance.

Now, L is proportional to the square of the number of turns in the coil, other things being the same. Hence, a coil having twice as many turns as another, all other conditions being constant, would have four times the inductance L. It might have practically four times the impedance, if R is negligibly small compared to $2\pi n L$. If you have, therefore, two coils of 500 turns connected in series and another coil of 1,000 turns, all other conditions being exactly the same, and the resistance so small in all coils in comparison with the product $2\pi n L$ that it can be neglected, then your two 500-turn coils together would only have about half the impedance of the single 1,000-turn coil. If the resistances are appreciable, the only way to get the total impedance of the two coils would be to calculate the impedance of each coil by the above formula and add the two together. (d) Multiply the capacity per mile given in your question by the length of one wire in miles. (e) No; such mixtures are called alloys. (f) Consult any work on Mechanics—Dana's or Wood's are good elementary works.

***

(428) (a) In what way can I find the power in foot-pounds required to run a machine? (b) How is a dynamometer constructed, and will it answer my purpose? (c) I have four paraffin tanks 6 ft. × 10 in. × 6 in., each. Each tank has a coil of steam pipe made of 22 feet of $\frac{1}{2}$-inch pipe. The paraffin is kept at 180°. How can I tell the amount of steam used per tank per hour? Please do not use algebra.

J. W. G., Philadelphia, Pa.

ANS.—(a) By the use of a transmission dynamometer. (b) See answer to inquiry No. 376 in this issue. (c) We do not think that you can calculate the steam used by any simple method. Why not condense the steam and weigh it?

***

(429) Please tell me how to melt celluloid.

A. J., Hull, Que.

ANS.—You cannot melt celluloid. It is an extremely inflammable and explosive compound. Celluloid is shaped as a soft bulby mass by hydraulic pressure, similarly to papier mâché.

***

(430) Given, two gas engines having the same volume of piston displacement per stroke, one with a long stroke and small diameter of cylinder, and the other with a short stroke and a large diameter of cylinder. Should there be any difference in the weight of the flywheels?

H. H. S., Hagerstown, Md.

ANS.—Assuming the diameter of the flywheels, the number of revolutions per minute, and the power of the two engines to be the same, theoretical considerations show that the one having the shorter stroke should have the heavier flywheel; however, most practical rules for calculating flywheel weights give results that are independent of the ratio of stroke to cylinder diameter.

***

(431) Having given the dimensions of a pair of rolls for rolling steel at the usual rolling heat, and the dimensions of the piece to be rolled, both before and after it passes through the rolls, so that the amount of reduction in the rolls is known, how can the torque required to drive the rolls be calculated, neglecting the friction of the rolls in their bearings?

C. J. S., Philadelphia, Pa.

ANS.—We do not know of any reliable method of making such a calculation.

***

(432) Each cylinder of a double hoisting engine has connections for a $1\frac{1}{4}$-inch steam pipe and a $1\frac{1}{2}$-inch exhaust pipe. A says that the combined exhaust from both cylinders may be discharged through a single $1\frac{1}{2}$-inch pipe, while B says that nothing less than a 2-inch pipe will carry the exhaust from the two cylinders. Please give your opinion concerning this matter. E. S., Minnehaha, Minn.

ANS.—A $1\frac{1}{2}$-inch pipe, if not too long, would probably discharge the exhaust from the two cylinders without producing a serious amount of back pressure. A 2-inch pipe, however, would secure a freer exhaust, and is to be recommended.

***

(433) (a) Could I use brass for making a $1\frac{1}{2}$″ × 6″ gasoline-engine cylinder? (b) Where could I get a telegraph instrument suitable for a beginner?

H. A. M., Franklin, La.

ANS.—(a) Brass could be used for such a cylinder, but it should be provided with a thoroughly efficient water-jacket that will prevent the cylinder from becoming too highly heated. (b) From The Technical Supply Company, Scranton, Pa. Price for instrument only will vary from \$2.00 to \$4.00, according to quality.

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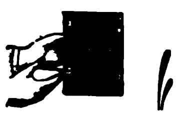

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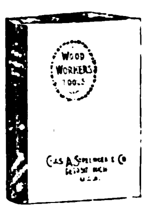

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